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APPLIED MECHANICS REVIEWS

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RECENT ADVANCES IN THE BUCKLING OF THIN SHELLS

WILLIAM A. NASH

PROFESSOR OF ENGINEERING MECHANICS, UNIVERSITY OF FLORIDA

The importance of the field of shell analysis is evidenced by the fact that in August, 1959, the International Union of Theoretical and Applied Mechanics conducted a symposium on the theory of thin elastic shells in Delft, Holland. This special meeting was attended by approximately 65 scientists in this field from 14 countries. This symposium indicated that considerable interest currently exists in such relatively new topics as the buckling of bimetallic shells, pressurized shells, creep buckling, and dynamic buckling, as well as in the more traditional problems involving isotropic shells of various geometries.

SINGLE-LAYERED ISOTROPIC SHELLS

The use of nonlinear theory has become rather widely accepted as a plausible basis for analytical predictions of elastic buckling strengths of thin shells of various geometries. The basic concepts of finite-deflection analysis due to Donnell (1) have been employed by numerous investigators to establish collapse loads of cylindrical shells subject to various loadings. Analyses in good agreement with tests on axially compressed cylinders have been presented by Donnell and Wan (2) and also Kempner (3). The former treatment includes a specific consideration of initial imperfections and illustrates the great sensitivity of the compressed cylinder to initial defects. The possibility of a second equilibrium configuration in the postbuckled region has been observed by Thielemann (4). This configuration differs considerably from the load-deflection relations presented in (3), terminating abruptly without merging with the usual solution.

The collapse loads of cylindrical shells subject to torsion have been investigated by Loo (5) and Krivosheev (6). The results of these finite-deflection studies are in good agreement with experimental evidence and illustrate that a cylinder in torsion is not as sensitive to initial imperfections as the same shell when loaded in axial compression.

The problem of the hydrostatically loaded cylinder has been treated by Kempner and Crouzet-Pascal (7) and also by Donnell(8) on the basis of finite deflections. In the latter work it is shown that, if reasonable imperfections are assumed, failure loads initiated by yielding are found to be of the same order as those indicated by experiments carried out at the David Taylor Model Basin. The sensitivity of a hydrostatically loaded cylinder to initial imperfections is intermediate to the cases of torsion and axial compression. Extensive tables for the predictions of the Euler critical load (infinitesimal theory), the Tsien critical load (elastic snap-through theory), and the postbuckling behavior of a hydrostatically loaded cylinder have been prepared by Langhaar and Boresi (9). These tables indicate certain discrepancies between the classical von Mises theory (10) and the infinitesimal-deflection theory resulting as a special case of (9). These deviations are greatest for short thick shells. For long slender shells the Euler buckling coefficient is shown to be only slightly higher than the Tsien coefficient, but for very small length-radius ratios the Euler coefficient can exceed the Tsien value by as much as 35%.

Finite-deflection analysis has also been successful in offering realistic predictions of the elastic buckling loads of shallow spherical caps subject to uniformly distributed external pressure. Kaplan and Fung (11) have presented a perturbation solution to the nonlinear equations that agrees quite well with results of their experiments for very shallow clamped-edge shells. Later, Archer (12) extended these results for a greater range of shells. This problem has also been successfully attacked by power-series techniques in conjunction with extensive use of digital computing facilities by Reiss, Greenberg, and Keller (13). This approach yields excellent values of the initial buckling load for a wide range of values of the shell parameters. A simplified approach based upon solutions to two linearized versions of the original nonlinear problem was later presented by Reiss (14).

These analyses of the buckling of the shallow spherical cap are limited to the case of axisymmetric deformations. The case of asymmetrical buckling of such a shell has been considered recently by Grigoliuk (15), who demonstrates the possibility of such action for certain geometric parameters. The nonlinear equations are solved approximately by Galerkin's procedure.

The buckling of an initially imperfect complete spherical shell subject to external pressure has been investigated by Donnell (16) with the aid of large-deflection theory. This study indicates that the sphere is relatively insensitive to initial defects. A semiempirical analysis of the buckling of a shallow spherical shell subjected to a concentrically applied ring-type load acting normal to the surface has been presented by Chien and Hu (17), and the buckling of this same shell

loaded by a single centrally located concentrated force has been analyzed recently by Ashwell (18).

Thus, finite-deflection studies are available for cylindrical and spherical shells subject to a variety of loadings and boundary conditions. In all cases the predictions of these theories are in better agreement with experimental evidence than those of the classical investigations based upon infinitesimal deformations. Unfortunately, the finite-deflection analysis of a thin conical shell has not yet been carried out. The buckling loads corresponding to uniform external pressure and axial compression respectively have been determined on the basis of infinitesimal-deformation theory by Taylor (19) and Hoff and Singer (20) for the former case and by Seide (21) for the latter. Axial compression accompanied by external pressure has been investigated by Mushtari and Sachenkov (22) with the same theory.

Few experiments pertaining to the buckling characteristics of either complete cones or frustums of cones have been reported. A comprehensive series of tests has been carried out by Jordan (23) on complete aluminum-alloy cones. As a result of these tests an empirical formula is presented which is probably adequate for many design purposes.

SHELLS WITH INTERNAL PRESSURE

Analytical studies have indicated that the effect of uniform internal pressure on the buckling of an axially compressed thin-walled cylindrical shell depends on the dimensionless parameter $\bar{p} = (p/E)(R/t)^2$ where p denotes the internal pressure, E represents Young's modulus, R is the radius of the cylinder, and t the shell thickness. Finite-deflection analysis indicates that the critical buckling stress should increase from a value of $\bar{\sigma}_{cr} = 0.376$ for $\bar{p} = 0$ to a value of $\bar{\sigma}_{cr} = 0.606$ at $\bar{p} = 0.169$, after which the buckling stress remains constant and equal to the classical value given by small-deflection theory. Tests conducted by Fung and Sechler (24) on aluminum-alloy cylinders indicate buckling stresses $\bar{\sigma}_{cr}$ much lower than the values predicted by this type of analysis, although the general trend of variation of $\bar{\sigma}_{cr}$ with pressure agrees with that predicted by theory. However, if the increment of $\bar{\sigma}_{cr}$, i.e. $\Delta\bar{\sigma}_{cr} = \bar{\sigma}_{cr} - \bar{\sigma}_{cr_0}$ where $\bar{\sigma}_{cr_0}$ is the value of $\bar{\sigma}_{cr}$ at zero pressure, be plotted against $\bar{p}$, then test results agree quite well with theory. These tests are due to Harris, Suer, Skene, and Benjamin (25) as well as Fung and Sechler (24). An extension of the nonlinear analysis to the case of orthotropic shells has been presented recently by Schnell (26).

STIFFENED SHELLS

One of the problems of greatest practical interest is that of the collapse of a reinforced shell when both the shell and stiffeners collapse simultaneously, in what is termed a general instability failure. The case of a ring-stiffened cylindrical shell subject to external hydrostatic pressure has been considered by Salerno and Levine (27), Alfutov (28), and Kendrick (29) on the basis of infinitesimal-deflection theory. The predictions of the latter analysis deviate at most by 20% from carefully conducted tests carried out at the David Taylor Model Basin. However, it should be observed that the boundary conditions employed in (29) do not agree with those existing in the test specimens. When classical theory is extended to the boundary conditions existing in the models, it is found that such a theory overestimates buckling pressures by as much as 70% of the experimental values. To date no analysis based upon finite-deflection theory has been carried out.

The general instability of a ring-stiffened cylindrical shell subject to axial compression has been investigated with the aid of plastic models by McCoy (30). It is interesting to note that these experiments indicate that the torsional stiffness of the rings is the most important parameter for stiffening the cylinder. Infinitesimal-deflection theory has been employed to investigate the buckling of an axially compressed cylindrical shell reinforced with equally spaced, identical stringers (31), and the results of such an analysis are in reasonable agreement with experiments conducted by Ponsford (32) on shells having radius-thickness ratios less than 335. The analytical results indicate that for certain geometries the presence of stiffeners does not increase the buckling stress over that of an unstiffened cylinder.

A comprehensive series of tests on nonshallow spherical caps reinforced by radial and ring-type stiffeners and loaded by uniform normal pressure has been carried out by Kloppel and Jungbluth (33). Ebner (34) has presented a small-deflection analysis which explains the behavior of those specimens that buckled into an axisymmetric pattern. However, a number of the models deformed unsymmetrically with the buckle forming at the boundary.

THERMAL EFFECTS

Recent developments have made it possible to predict the peak temperature to which a cylindrical shell may be subjected prior to thermal buckling when the temperature varies only in the circumferential direction. An analysis by Lu (35) has indicated the importance of the circumferential temperature gradient and demonstrates that maximum temperature alone is not the sole criterion for thermal buckling. This analysis is based upon an extension of Donnell's linear eighth-order equation, which is then solved by Galerkin's method. Lu conducted a series of tests on brass shells subject to a circumferential temperature change and found that the results of these experiments agree closely with the analysis for shells having radius-thickness ratios in excess of 500. A variation of this analysis, leading to approximately the same results, has been presented by Abir and Nardo (36). Later, Abir and others (37) considered thermal buckling of both stiffened and unstiffened conical shells. The reinforced cones were heated uniformly, and their buckling time was found to be greater than that predicted by infinitesimal-deflection theory. It was demonstrated that there is little possibility of thermal buckling of an unreinforced conical shell heated axisymmetrically with a variation of heat input in the axial direction.

One of the more significant problems associated with thermal effects in structures is that of creep buckling. Because of mathematical difficulties associated with the analysis of a bending resistant isotropic shell it has been possible to date to investigate only a sandwich-type shell with the concentric cylindrical shells supporting the normal loads and the annular core supporting the shear loads. If a cubic creep law is assumed, it is possible to develop an equation for the time behavior of the shape of the cross section of a long cylindrical shell under uniform external radial pressure. Hoff, Jahsman, and Nachbar (38) have obtained an explicit solution for the collapse time versus initial amplitude for this case. A treatment by Sundstrom (39) permits a consideration of axial forces in addition to the radial pressure, but the solution is obtained only in implicit form. The concept of sandwich shell together with a biaxial creep law has recently been used by French and Patel (40) to determine axisymmetric creep buckling characteristics of a cylindrical shell subject to axial compression. Tests conducted by Mathauser and Berkovits (41) have led to a semiempirical procedure for analysis of creep buckling of cylindrical shells loaded in pure bending.

DYNAMICALLY LOADED SHELLS

The problem of buckling of shells subject to dynamic loading has come under consideration only in the past few years. A series of unstiffened aluminum shells has been dynamically collapsed by the axial impact of a high velocity mass (42) to indicate a mode of buckling failure somewhat different from

that of the static case. In this series the failure mode is the same diamond pattern found in static tests, but it develops uniformly over the entire shell. The wavelengths of these patterns decrease with increasing impact velocity. It is interesting to note that the energy absorbed in the dynamic buckling case is greater than that absorbed in slow, static tests.

The first analytical investigations of the dynamic stability of both cylindrical and spherical shells are due to Bolotin (43). The problems of a cylindrical shell subject to axial compression as well as radial pressure, and also a spherical shell subject to uniform radial pressure, were investigated on the basis of infinitesimal-deflection theory. More recently Agamirov and Vol'mir (44) have extended the treatment of the former problem to include finite-deflection effects. The dynamic stability of a shallow cylindrical panel subject to axial compression has also been analyzed on the basis of nonlinear theory by Vol'mir (45). Insufficient experimental data are available to establish completely the validity of any of these theories.

MULTILAYERED SHELLS

Analogous to the buckling of dynamically loaded shells, the problem of elastic instability of laminated shells has attracted attention only very recently. To date existing theories have been limited to the analysis of two-layered shells wherein the thickness of each layer is constant and it is assumed that the surfaces at the bond cannot slide against one another.

The first treatments of buckling of two-layered cylindrical and conical shells loaded by uniform external pressure are due to Grigoliuk (46), (47), who employs finite-deflection theory to obtain buckling loads of these shells. These studies consider the bonding surface as the reference surface. A revision of these analyses, in which the reference surface is determined by setting the first moment of the Young's moduli equal to zero, has been offered by Radkowski (48), (49), who uses the Rayleigh-Ritz method in conjunction with classical theory to obtain estimates of the buckling loads. Unfortunately, no experimental results are available for multilayer shells.

SANDWICH SHELLS

In the case of homogeneous isotropic cylinders it is well known that classical linear theory yields buckling loads much higher than those observed in experiments. However, for the case of circular sandwich cylinders with shear weak cores linear theory predicts buckling loads quite accurately. Wang and de Santo (50) have investigated the buckling of such sandwich cylinders under axial compression, torsion, bending, and combined loads on the basis of an extension of Donnell's eighth-order small-deflection equation. The equation is readily solved by Galerkin's method for these cases to yield the critical loads. For the case of axial compression, for example, the critical axial stress is found to be independent of the wave length and is given by

$$\sigma_{cr} = \frac{(h + t)\, G_c}{2t},$$

where h is the core thickness, t the facing thickness, and G_c the shear modulus of the core.

Test results from aluminum-alloy-faced sandwich cylinders with cellular cellulose acetate cores (50) indicate the reliability of the above expression. Expressions of corresponding simplicity are found for the cases of torsion and bending. For combined loadings the solution of the Donnell equation leads to nondimensional interaction curves.

It is interesting to observe that the buckle patterns observed during axial compression of these specimens were diamond shaped, but with a circumferential wavelength approximately three times that in the axial direction. For a homogeneous cylinder these wavelengths are usually approximately equal.

Extensions of this type of analysis to the case of a sandwich cylinder having orthotropic facings have been carried out, at the Forest Products Laboratory, for axial compression (51), torsion (52), and uniform radial pressure (53) respectively. Experimental investigations carried out at this laboratory have confirmed the validity of the nonlinear theory developed in (51) and the linear theories derived in (52) and (53) respectively.

SUMMARY

In conclusion, mention should be made of excellent surveys of structural stability by Gerard and Becker (54) and later by Gerard (55). The rather recent books by Flugge (56), by Vol'mir (57), by Mushtari and Galimov (58), and also by Oniashvili (59) all present detailed expositions of many areas of the shell buckling problem.

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58 Mushtari, K. M., and Galimov, K. Z., "Nonlinear theory of elastic shells," Tatknigoizdat, Kazan, 1957.

59 Oniashvili, O. D., "Some dynamic problems in the theory of shells," *Akad. Nauk SSSR*, Moscow, 1957.

Analytical Methods in Applied Mechanics

(See also Revs. 1061, 1089, 1093, 1133, 1134, 1149, 1162, 1163, 1165, 1203, 1220, 1293, 1296, 1457, 1468, 1504)

1040. Rabenstein, A. L., The determination of the inverse matrix for a basic reference equation for the theory of hydrodynamic stability, *Arch. Rational Mech. Anal.* **2**, 4, 355–366, Jan. 1959.

In the asymptotic theory for the Orr-Sommerfeld equation of hydrodynamic stability, the equation

$$u^{iv} + \lambda^2(Zu'' + \alpha u' + \beta u) = 0 \qquad [1]$$

plays the role of a reference equation. Author determines the asymptotic behavior, for large $|\lambda|$, of the inverse matrices corresponding to various fundamental matrix solutions of [1]. Paper contains the formulas which express the third-order Wronskians of the solutions of [1], in terms of the solutions of the adjoint equation

$$v^{iv} + \lambda^2[zv'' + (2 - \alpha)v' + \beta v] = 0$$

Paper is rather of a mathematical interest.

D. G. Ionescu, Roumania

1041. Culick, F. E. C., Effects of small changes in the elements A_{ij} on the zeros of $|A_{ij}|$, *J. Roy. Aero. Soc.* **62**, 576, 898–901 (Technical Notes), Dec. 1958.

A procedure is outlined, in the context of the free motion of a dynamical system, for determining the effects of small variations in the elements of a determinant on its zeros. The case of repeated zeros is treated. Possible application to stability of a dynamical system is shown by example. Author notes applicability of method outside chosen context.

T. P. Mitchell, USA

1042. Zurmuhl, R., Calculation of bending vibration of stepped shafts with transitive conditions with the help of transfer matrixes (in German), *Ing.-Arch.* **26**, 6, 398–407, Dec. 1958.

An interesting method based on the calculation of matrixes is presented to find the lowest natural frequency of bending vibration of stepped shaft. The method does not require the use of a computer and leads to nearly exact results even though the division of the span length is rather coarse.

The load vector, the components of which are proportional to the deflection in the case of loading by inertia forces, is approximated by a simplified Hermite interpolation formula. The fulfilment of the second group of end conditions presents a certain matrix equation which is solved by iteration method (Mises). Author investigates the modification of described method in the cases of elastic supports and internal transitive conditions (hinges).

To follow the paper knowledge of calculus of matrixes is required.

K. Julis, Czechoslovakia

1043. Goldbaum, Ia. S., On a transformation of the secular equation, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **22**, 4, 750–753, 1958. (Pergamon Press, 122 E. 55th St., New York, 22, N. Y.)

Book—1044. Pinney, E., Ordinary difference-differential equations, Berkeley, Calif., Univ. of Calif. Press, 1958, xii + 262 pp. $5.

Ordinary difference-differential equations play an increasing role in various fields of engineering, in economics, etc. Studies of particular equations have been published in many places and an individual confronted with solving a special problem may easily overlook earlier work. This difficulty has been removed by the present book. Author has collected the available investigations, made a kind of catalog and put their solutions in a general framework. Actually, the system of difference-differential equations dealt with in the beginning of the book is so general that it may be hard on many readers to work through these chapters when the solution of a much simpler single equation is needed. Author, who worked for some time together with N. Minorsky, devotes the last three chapters to nonlinear difference-differential equations and their special features. These chapters are particularly interesting since nonlinear effects are gaining in importance.

Irmgard Flugge-Lotz, USA

1045. Karamyshkin, V. V., Transformation of a linear differential equation with polynomial coefficients into an integral equation with the aid of operational calculus, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **22**, 4, 774–776, 1958. (Pergamon Press, 122 E. 55th St., New York, 22, N. Y.)

Book—1046. Sparenberg, J. A., Application of the Hilbert problem to problems of mathematical physics, Delft, Holland, Library of the Technological University, 1957, 73 pp. + ref. (Paperbound)

The problems dealt with in this book can all be formulated in terms of the Hilbert problem. The mode of solution employed throughout is that of application of sectionally holomorphic functions. These functions are regular in the entire complex domain with the exception of a discontinuity on a certain characteristic curve of the problem.

The majority of the book is concerned with the Wiener-Hopf integral and integro-differential equations. Solutions of the problems of (a) an infinite elastic tube which is shrunk onto a semi-infinite rigid shaft (the contact pressure is formulated as an integral equation), (b) two-dimensional surface waves of a deep sea in the presence of a strip or dock of finite extent which is at rest on the level of the undisturbed water surface, as well as (c) the influence of the cross-sectional form of a ship on the added mass for higher-order vibrations, are presented in detail. These last two problems are formulated as integro-differential equations.

General discussions are presented for the solutions of Wiener-Hopf-type integral and integro-differential equations, the latter being restricted to the presence of either first- or fourth-order derivatives.

W. A. Nash, USA

1047. Kaplan, S., and Sonnemann, G., A generalization of the finite integral transform technique and tables of special cases, Proc. Fourth Midwest. Conf. Solid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 1959, 497–513.

Finite integral technique is used to obtain solutions of boundary-value problems of heat conduction in the form of expansions in series of orthogonal functions. Possible extension to wave equation and telegraph equation is indicated. The treatment is purely formal and the results are those obtained by separation of variables. However, the treatment is unified to include heat generation (dependent on position and time only) and the general boundary condition $a(r)k\nabla\phi\cdot n = b(r)\phi + j(r,t)$ where r is a position vector, ϕ is surface temperature, and $k\nabla\phi\cdot n$ is heat flux through the surface. A table of solutions is given for a number of problems with simple geometry: one-dimension, cylinder, sphere. The "inversion formulas" are known formulas for expansions in series of orthogonal functions.

References to previous work are lacking. Following texts may be mentioned: R. V. Churchill, "Operational mathematics," McGraw-Hill, 1958, Chap. 10; I. N. Sneddon, "Fourier transforms," McGraw-Hill, 1951, Chaps. 3 and 5.

H. G. Landau, USA

1048. Riabokin, T., A treatise on Lissajous figures and Tchebycheff polynomials, Univ. of Minn., Inst. of Technol., Rosemount Aero. Lab. Res. Rep. 146, vi + 108 pp., 1958.

Title figures are usually defined in parametric form by $x = a \sin(smt)$, $y = b \sin(snt + \alpha)$, where s is rational. Author shows that figures may be characterized using Chebyshev polynomials. Singular points are defined and a method for finding these points is described. There are many examples and illustrations.

Y. L. Luke, USA

Computing Methods and Computers

(See also Revs. 1064, 1068, 1070, 1078, 1087, 1165, 1306, 1317, 1357)

1049. Svensson, H., A useful simplification of the method of least squares, *Sci. Tools—LKB Instrum. J.* **6**, 1, 1–3, Apr. 1959.

When fixed variable values are equidistant and symmetrically spaced around the origin, the normal equation may be solved rather easily as the odd power terms vanish. Using author's table of such values as $(m\Sigma x_i^4 - \Sigma x_i^2 \Sigma x_i^4)$, the fitting of polynomials of third degree reduces to the computation of four second-order determinant values. Reviewer prefers, however, the well-known Chebyshev-Fisher orthogonal polynomials method [see e.g. Anderson, R. L. and E. E. Houseman, *Iowa State Coll. Agric., Exp. Sta. Res. Bull.* no. 297, 1942] for this case. Concerning the way to handle general ill-conditioned equations, about which author worries, reviewer recommends M. E. Terry's transformation proposed in "Curve fitting and automatic computers" [15-p. mimeographed note].

M. Sibuya, Japan

1050. Ungar, E. E., Numerical integration simplifies complex design, *Prod. Engng.* **30**, 11, 50–54, Mar. 1959.

1051. Milsum, J. H., Transfer-function discovery on the PACE analogue computer, Nat. Res. Counc. Canada, Div. Mech. Engng. Rep. MK-2, 34 pp., Feb. 1959.

Purpose of reported investigation is to determine the accuracy and speed with which transfer functions could be obtained from records to an arbitrary input transient and corresponding output response, using a matching procedure on the PACE analog computer; the form of the transfer function being known or guessed, the coefficients being determined by matching. Investigation was limited to linear systems. A typical aircraft configuration—suggested by current local interests and in view of available reported results in other investigations—was selected.

A simple degenerate class of aircraft motion—longitudinal modes uncoupled from lateral modes, phugoid mode omitted—leads to characterization of transfer function as the ratio of a linear to quadratic polynomials in the Laplace parameter s. Triangular pulse input was utilized. Experimental work shows that "mask" matching technique enables ready determination of constants, up to a maximum number of four, within a few minutes to an accuracy of better than one per cent. The conventional transient and frequency responses are immediately obtainable from the transfer function; whence the procedure affords more information than does determination of frequency response only from the transient response. T. J. Higgins, USA

1052. Isobe, T., Hatanaka, H., and Uchida, I., Automatic curve follower using polarized light beam chopper, *Aero. Res. Inst., Tokyo, Rep.* no. 340, 24, 11, 9 pp., Dec. 1958.

This paper describes a new automatic curve follower, which can follow a graph given in a thin black line on a white paper or a curve photographically recorded as an oscillogram. The detector consists of two illuminators of the line to be followed, a microscope objective lens by which the image of the line is formed, a polaroid disk which is fixed at the image plane and is divided into two equal parts having their principal planes perpendicular to each other, a rotating polaroid disk driven by a synchronous motor, and a phototube. The beam of light passed successively through the two polaroid disks flickers alternately at the two parts of the field. But the total flux, which the phototube receives, remains constant if the curve runs through the center of the field. When the curve deviates from this position, the deviation is picked up by the phototube as an alternating change of the total light flux having an amplitude proportional to the deviation and a reverse phase corresponding to its direction. This detector is a servomechanism operating in conjunction with a voltage amplifier, a thyratron circuit and a split field motor, which drives the lead screw of the follower. From authors' summary

1053. Rao, J. V. R., Solution of simultaneous differential equations using analog computers (in English), *J. Sci. Engng. Res., India* **2,** 2, 215–220, July 1958.

Analog computers can be used to solve a set of simultaneous differential equations representing a system, and the nature of variation of the dependent variables can be obtained in the graphical form. A pulse-forming network using lumped impedances can be represented by a set of simultaneous differential equations and this system is analyzed from the point of view of computational technique. From author's summary

Analogies

(See also Revs. 1072, 1332, 1406, 1492)

1054. van Heerden, P. J., On the analogy between dynamics and a game of cards, *Amer. J. Phys.* **27,** 2, 103–111, Feb. 1959.

It is shown that there is an analogy between dynamics and a simple game of cards. The dynamical quantities like velocity, mass, momentum, and kinetic and potential energy find their equivalents in the card game.

From author's summary by H. D. Block, USA

1055. Chetaev, N. G., On the extension of the optical-mechanical analogy, *Appl. Math Mech. (Prikl. Mat. Mekh.)* **22,** 4, 678–681, 1958. (Pergamon Press, 122 E. 55th St., New York, 22, N. Y.)

1056. Belgaumkar, B. M., Characteristics of series; electrical circuit used as an analogue for mechanical vibration system, Proc. 2nd Congr. Theor. Appl. Mech., New Delhi, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur 1956; pp. 199–208.

1057. Loh, W. H. T., Hydraulic analogy for two-dimensional and one-dimensional flows, *J. Aero/Space Sci.* **26,** 6, 389–391 (Readers' Forum), June 1959.

Analogies between gas and water flow are extended in an excellent comparative manner. Analogous equations of continuity, momentum, and energy are presented in significant dimensionless forms. Author first presents familiar similarity of equations for two-dimensional steady flow of an isentropic gas of specific heat 2.0 with frictionless water flow in horizontal open channels.

Author explains that similar analogies for one-dimensional unsteady flow were examined by him in 1944, but never published; at that time he found identical mathematical form for equations of isentropic perfect gas of any specific heat and incompressible frictionless water in open channel of cross section $z = C y^n$. Paper being reviewed resulted from a suggestion to author that publication of these equations for one-dimensional unsteady flow analogies would be of value.

Local ratios and equations in gas and water flow are presented clearly in parallel fashion, which the reviewer considers convenient for easy understanding and reference. Author's paper and references will be useful to experimenters planning simple water tests to represent flow of transient or high-speed effects in gas flow. L. M. Laushey, USA

1058. Mashovets, V. P., and Korobov, M. A., Conditions of electric simulation of a thermal field with internal heat sources, *Soviet Phys.-Tech. Phys.* **3,** 10, 1952–1957, June 1959. (Translation of *Zh. Tekh. Fiz.* **28,** 10, 2124–2129, Oct. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Primarily the paper comprises determination of dimensionless quantities characterizing electroanalogic simulation of thermal problems characterized by internal generation of heat. Various boundary conditions such as constant temperature, convective heat transfer, and so forth, are included as separate cases of the general treatment. Given references are all to Soviet literature. This paper can be read with interest and profit by anyone concerned with the stated type of problem. Specific mention re use of developed theory is in design of anodes in electrical production of aluminum; or in kindred electrometallurgical operations. T. J. Higgins, USA

Kinematics, Rigid Dynamics and Oscillations

(See also Revs. 1041, 1356, 1448, 1492, 1575, 1576)

1059. Chetaev, N. G., On a gyroscope mounted in a universal suspension (on gimbals), *Appl. Math Mech. (Prikl. Mat. Mekh.)* **22,** 3, 521–525, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Author derives the equations of motion of a pendulous gyroscope whose outer gimbal axis is vertical, taking into account the gimbal inertias. He then discusses precession and nutation along lines of spinning-top theory. L. Maunder, Scotland

1060. Misicu, M., On the Boussinesq and Hertz's dynamic problems (in Roumanian), *Studii Si Cercetari Mecan. Appl.* **10**, 2, 467–496, 1959.

Author discusses the steady case of the dynamic problems of Boussinesq and Hertz. Assuming that normal loads act on the separation plane of the elastic half space according to a harmonic law, he determines the stress and strain states. For the case of the contact problem, the elliptic disk is particularly discussed.

P. P. Teodorescu, Roumania

1061. Atkinson, C. P., and Bourne, C. P., The solution of Duffing's equation for the softening spring system using the Ritz-Galerkin method with a three term approximation, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 71–77.

The equation $\ddot{q} + q - (4/3)\, q^3 = F \cos \omega t$ is solved using the assumption $q = A \cos \omega t + B \cos 3\omega t + C \cos 5\omega t$. The algebraic equations for the amplitudes A, B, and C are presented and solved on an IBM 701 computer by means of iteration. For the free vibrations ($F = 0$) the third and fifth harmonic increase in amplitude with decreasing frequency. For the forced vibrations the amplitudes of the fundamental component are higher than in the single-term approximation. For the range $0.075 < \omega^2 < 0.1$ oscillations due to forcing functions greater than $F = 0.2$ can become unstable since the sum of the three components may produce a q_{max} that will extend into the unstable region.

G. W. Braun, USA

1062. Ludeke, C. A., and Pong, W., Concerning subharmonic oscillations which may exist in nonlinear systems having odd restoring forces, *Trans. ASME*, **81** D (*J. Basic Engng.*), 1, 37–40, Mar. 1959.

An experimental study is made of subharmonic oscillations in systems having $|\theta|\theta$, θ^3, and $|\theta^3|\theta$ as the nonlinear terms in the restoring force; θ represents displacement. In a system with a restoring force θ^3 the subharmonic of order one third was the only subharmonic observed. In a system with $|\theta|\theta$ or $|\theta^3|\theta$ as the restoring force, subharmonics of order one half and one third were observed.

From authors' summary

1063. Mahalingam, S., An improvement on the Holzer method, *J. Appl. Mech.* **25**, 4, 618–620 (Brief Notes), Dec. 1958.

Paper presents a method of obtaining the next trial frequency from the results given by the previous Holzer table. The basis of the method is the effect of a small (fictitious) change in moment of inertia on the natural frequency of the torsional system. Although basically different, the method leads to a result which is very close to that given by Crandall and Strang [*J. Appl. Mech.* **24**, 228–230, 1957; AMR **10** (1957), Rev. 2032]. The relative merits of the two methods depend on whether the trial frequency is above or below the exact one and on whether or not the next approximation will overshoot the exact value.

From author's summary

1064. Ungar, E. E., Numerical integration works with dynamic systems too, *Prod. Engng.* **30**, 17, 64–66, Apr. 1959.

1065. Kharlamova, E. I., Rolling of a sphere on an inclined plane, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **22**, 4, 701–708, 1958. (Pergamon Press, 122 E. 55th St., New York, 22, N. Y.)

1066. Mikhailov, G. K., On Leonhard Euler's unpublished notes and manuscripts on mechanics, Proc. 3rd Congr. Theor. Appl. Mech., Bangalore, India; Kharagpur, Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., 1957; 19–24.

Instrumentation and Automatic Control

(See also Revs. 1051, 1059, 1337, 1374, 1440, 1441)

Book—1067. George, F. H., Automation, cybernetics, and society, New York, Philosophical Library, 1959, 283 pp. $12.

This book covers a very wide range of subjects in giving a comprehensive survey of the fields of cybernetics (defined as the comparative study of the control system formed by the nervous system and brain and mechanical electrical communication systems) and automation. Although these sciences usually involve much mathematical description the author has produced a text almost completely free from mathematical statements, and the few used are only in illustrative examples. Author traces the interrelation of mathematical logic, automatic machines, communication systems, physiology, psychology and social science.

The book is divided into three main parts covering (1) the social background of automation, (2) cybernetics and automation, (3) operational research and automation. The last three chapters covering the future of automation, the automatic factory and the future of civilization are of particular interest, giving, as they do, the author's predictions of possible developments and problems and pointing out the importance of these to our economy and individual well-being. Each chapter is followed by a short list of pertinent references and the book concludes with a complete index of people to whom reference is made in the text. This is a book which will be of interest to workers in the fields covered and probably even more so to those who are just meeting some of the sciences for the first time in their work. It is excellently produced and very well written. Reviewer enjoyed reading it and has found it requires much more study to get the full benefit. It can be thoroughly recommended.

A. F. W. Langford, Australia

1068. Hellman, O., On the iterative solution of the equations of a single-loop system with one non-linearity, *J. Elec. Control* **6**, 2, 186–192, Feb. 1959.

The method proposed may be regarded as a modification of the method employed in the Hilbert-Schmidt theory of linear integral equations. The equation of the subject is first substituted by a system of infinite number of nonlinear algebraic equations in which the Fourier coefficients of the expected periodic solution are unknowns. This system of nonlinear algebraic equations is then solved by the iterative method.

S. Fujii, Japan

1069. Flugge-Lotz, I., Taylor, C. F., and Lindberg, H. E., Investigation of a nonlinear control system, NACA Rep. 1391, 34 pp., 1958.

See AMR **10** (1957), Rev. 3540.

1070. Auerbach, I. L., Digital systems in control applications, ASME Design Engng. Conf., Philadelphia, Pa., May 1959. Pap. 59-MD-9, 7 pp.

Discussed are the underlying principles involved in translating dimensional data from a drawing to a part in metal produced on a numerical controlled machine. Examples are given of point-to-point positioning and contouring. Systems engineering concepts are outlined.

From author's summary

1071. Pistiner, J. S., On-off control system for attitude stabilization of a space vehicle, *ARS J.* **29**, 4, 283–289, Apr. 1959.

Author discusses the bang-bang control of the attitude of a space vehicle. To illustrate the method he develops the theory for pitch control. Control trajectories are plotted on the phase plane. Stable limit cycle operation is achieved by the use of a

lead network. The effects of hysteresis, dead zone and time delays are covered. The selection of lead network parameters to minimize fuel consumption is discussed. The paper closes with a method of measuring time along phase curves. The on-off thrust control is accomplished with an electrical network controlling gas jets, the error in pitch being sensed by a phase-sensitive detector.
R. Oldenberger, USA

1072. Batkov, A. M., The solution of a single class of non-steady problems in the statistical dynamics of automatic control systems, using electron modelling devices (in Russian), Avtoref. Diss. Kand. Tekhn. Nauk, Mosk. Inzh.-fiz. In-ta, Moscow, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7391.

1073. Haeussermann, W., An attitude control system for space vehicles, *ARS J.* **29,** 3, 203–207, Mar. 1959.

An attitude control system, applicable to any size space vehicle, is proposed which uses expulsion charges to compensate for initial disturbances. Final fine control is exerted by a low-power flywheel reaction-type servo system which makes use of a specially designed d-c servo motor with an impedance-type commutator and transistor control. The d-c servo motor is able to work in vacuum. It is shown how the control system can be stabilized without direct derivatives of the attitude information; therefore, the system also supports stabilization when manually controlled. Some possibilities are mentioned to derive attitude information for space and Earth-fixed reference systems.
From author's summary

1074. Stewart, E. C., Druding, F., and Nishiura, T., The effects of target and missile characteristics on theoretical minimum miss distance for a beam-rider guidance system in the presence of noise, NASA Memo 2–12–59A, 32 pp., Mar. 1959.

Authors study the effects of target acceleration, glint noise, and missile acceleration capability on the minimum obtainable miss distance for a beam-rider navigation system, using random target maneuver models. For realistic values, the switching period of target acceleration has negligible effect on minimum obtainable miss distance. It is possible to formulate a simple functional relationship between miss distance and other factors empirically by having a sufficient number of specific solutions.
R. M. Stewart, USA

1075. Orlik-Ruckemann, K. J., Measurement of aerodynamic damping and stiffness derivatives in free oscillation with automatically recycled feedback excitation, Nat. Res. Counc., Canada, Aero Rep. LR–246, 11 pp., June 1959.

A dynamic test technique for obtaining the aerodynamic damping and stiffness derivatives is described. The technique is based on the method of free oscillation and it employs automatically recycled feedback excitation. The technique has been found to be very convenient, fast and accurate and is of particular interest for tests in intermittent wind tunnels because of its very efficient use of the short running times available.

The technique is presented together with a description of an experimental apparatus for oscillation-in-pitch tests on half models, where it was first used. The same technique can be used, of course, for any single-degree-of-freedom oscillation experiment.
From author's summary

1076. Orlik-Ruckemann, K. J., Some data on elevator damping and stiffness derivatives on a delta wing aircraft model at supersonic speeds, Nat. Res. Counc., Canada, Aero Rep. LR–250, 11 pp., June 1959.

Elevator hinge moment derivatives at supersonic speeds were determined on a half model of a delta wing aircraft, using an apparatus for free oscillation tests on small surfaces. The results obtained are compared with results of theoretical calculations.
From author's summary

1077. Staros, B., Gretz, R., and Mandel, M., Selection of an aerodynamic configuration for improved beam rider guidance, *ARS J.* **29,** 2, 115–118, Feb. 1959.

The beam-rider-type air-to-air missile system basically requires a missile with a fast response to acceleration commands. This characteristic is necessary for good synchronization with the beam at the beginning of missile flight and for good beam riding, in the presence of large beam rotation rates, and radar noise during the remainder of flight. A missile with a conventional wing control configuration which performs well at low altitude tends to have inadequate response at high altitude. The necessary improvement in response can be achieved either by an aerodynamic configuration which provides a very high missile pitching frequency or alternatively by a configuration which obtains all the lift by wing deflection alone. The latter configuration, essentially a no-α (no angle of attack) missile, is particularly interesting because it eliminates the dependence of missile response on altitude. This configuration yields substantial improvements in beam riding performance at high altitude. As secondary advantages, system simplification is achievable through the elimination of the need for rate gyro feedback to damp body oscillations and through the considerable reduction of induced rolling moments.
From authors' summary

1078. Tallman, C. R., Transducer frequency response evaluation for rocket instability research, *ARS J.* **29,** 2, 119–122, Feb. 1959.

A shock tube is used to generate step excitation of pressure transducers. Performance parameters, such as rise time, overshoot, and damping, are obtained directly from the transient response. The frequency response is obtained by an approximate method based on Laplace transforms [E. A. Guillemin, Proc, Nat. Electronics Conf., 1953; **9,** 1954] with the aid of a digital computer. Inherent errors of the approximation are estimated by applying the method to an oscillatory second-order system with damping. Results obtained for three commercial transducers are presented.
G. Rudinger, USA

1079. Sohn, R. L., Attitude stabilization by means of solar radiation pressure, *ARS J.* **29,** 5, 371–373 (Tech. Notes), May 1959.

Paper demonstrates the feasibility of stabilizing the attitude of a space vehicle by means of solar radiation pressure. If a suitable weathervane-type tail surface is attached to the vehicle, solar radiation pressure, acting on the weathervane, will stabilize the vehicle against disturbing torques which arise from gravitational eccentricities (dumbbell effect), meteorite impacts and solar radiation pressures.
From author's summary

1080. Lundstrom, R. R., and Whitman, Ruth I., Analytical investigation of a flicker-type roll control for a Mach number 6 missile with aerodynamic controls over an altitude range of 82,000 to 282,000 feet, NASA Memo 4–23–59L, 50 pp., May 1959.

Analog computer simulation is of particular interest in studies of possible ICBM defense. Effects considered were: Damping augmentation (rate factor), amplitude of aileron deflection, transient response to disturbances, structural asymmetries, actuator lag time, and the effect on stability of rapidly increasing attitude.
R. M. Stewart, USA

1081. Burt, D. A., An optimizing control for the process industries, ASME–AIEE–IRE Conf. Automatic Techniques., Chicago, Ill., May 1959. Pap. 59–AUT–4, 11 pp.

Automatic optimization is one of the newest concepts in the field of process control. An optimizing control attempts to adjust

the variables affecting a process in such a way as to maximize some criterion of performance, such as operating profit. The optimizing control system described, unlike a digital-computer control, requires a minimum of information about the process, and in particular does not require process equations. The heart of this control is a transistor-resistor logical system which makes changes in the controlled variables, observes results, and decides what to do next to improve operation. The development of such a control device is discussed, an application to a chemical process described, and operating results summarized.

From author's summary

1082. McCracken, J. G., Effects of gyroscopic cross coupling on missile automatic flight control systems, *Aero/Space Engng.* **17,** 11, 70–73, Nov. 1958.

Tables, Charts, Dictionaries, etc.

(See Rev. 1049)

Elasticity

(See also Revs. 1109, 1116, 1130, 1132, 1133, 1138, 1152, 1158, 1163, 1164, 1175, 1203, 1213, 1228, 1502, 1546)

1083. Brcic, V., A contribution to the solution of a plane stress problem of theory of elasticity (in Serbian), Univ. of Beograd, 111 pp., 1958.

A plate uniformly tensioned in one direction parallel to its medium plane and containing large openings was studied. Solution was obtained in three different ways: using equations of finite differences, photoelasticity, and functions of complex variable. For the finite difference solution, rough and fine networks were used for first and second stage of computation. Rough framework gave a system of 10 linear equations, solved by elimination. The fine network gave a system of 70, solved by relaxation.

Plate of the same shape was considered in photoelasticity and values of stresses for same discrete points as before were found. Material used for models was decorit. Principal stresses were obtained by numerical solution of Laplace equation for the same points in the interior of plate. Using Dirichlet's theorem for harmonic functions, this biharmonic problem was reduced to a harmonic one.

In third method problem was generalized by enlarging plate to infinity and complex potential was found using formulas of Muskhelishvili, transformed by Kikukawa. Plate was then transformed using a Schwartz-Christofel transformation.

Results obtained by the three methods were compared and found to be in good agreement, but stresses obtained by the third method increased more slowly toward the value of 1 along x-axis, because the range was taken as infinite. High-class theoretical and experimental work is demonstrated by the author in this interesting and valuable paper of practical importance.

B. Kuzmanovic, Africa

1084. Meissner, H., The calculation of stresses below arbitrary points, inside and outside of a uniformly loaded loose circular area (in German) *Bauingenieur* **33,** 9, 342–344, Sept. 1958.

No consideration is given explicitly to stress-strain relations or to compatibility. The assumption is made that the solution for the normal stress on horizontal planes at depth z below the surface can be built up by superposition of the concentrated force result taken as $(\nu P/2\pi z^2)\cos^{\nu+1}\theta$, where θ is the angle between the vertical and the radius from the point of application of the load P and ν is a constant called the concentration factor. Closed form answers are obtained for $\nu = 2.4$ and graphs are plotted.

D. C. Drucker, USA

1085. Amenzade, Iu. A., Local stresses in the bending of a circular prismatical beam with an elliptical non-coaxial hole, *Soviet Phys.-Doklady* **3,** 5, 1040–1044, May 1959. (Translation of *Doklady Akad. Nauk SSSR (N.S.)* **122,** 3, 356–360, Sept. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Author solves the problem by determination of a complex torsion function and of a second regular function of the complex variable $z = x + iy$ which satisfies boundary conditions.

Numerical solution of the resulting system of equations is accomplished by method of successive approximations. Results of an example are given in terms of shear stress distribution. Convergence and accuracy of method appear to be good.

A. F. Foerster, USA

1086. Ling, C.-B., Stresses in a stretched slab having a spherical cavity, *ASME Trans.* **81**E (*J. Appl. Mech.*), 2, 235–240, June 1959.

Paper gives a neat analytic solution for an infinite slab with one symmetric spherical cavity. Two sets of biharmonic functions giving zero tractions on the plane surfaces are combined to make the spherical surface stress free. Resulting infinite system of linear equations is solved by successive approximations. Numerical results are given for two sizes of cavity.

W. M. Shepherd, England

1087. Baltrukonis, J. H., Comparison of approximate solutions of the thermoelastic problem of the thick-walled tube, *J. Aero/Space Sci.* **26,** 6, 329–334, June 1959.

Axially symmetric, steady-state temperature distribution is assumed and thermal stresses are calculated, taking variation with temperature of elastic and thermal properties of the material into account. Five different methods are compared: (1) "Exact" solution by electronic digital computer; (2) incompressible material; (3) temperature-independent material with average properties; (4) temperature-independent material with weighted-average properties; (5) method of least squares. Of all approximations (5) gives best results.

In reviewer's opinion paper is of rather limited value. First, heat-transfer problem is not independent of thermal variation of material properties as author erroneously assumes and, second, creep and yield will occur at the high temperatures considered, thus introducing errors many times greater than those due to the various methods.

H. Parkus, Austria

1088. Sternberg, E., and Chakravorty, J. G., Thermal shock in an elastic body with a spherical cavity, *Quart. Appl. Math.* **17,** 2, 205–218, July 1959.

The elastic response of an infinite medium containing a spherical cavity is analyzed for the case of an instantaneously applied uniform temperature change at the wall of the cavity. The inertia terms are included in the solution of the thermokinetic problem. By means of the Laplace transform, a closed-form solution is obtained in terms of error functions of real and complex arguments. The numerical results show a pronounced oscillation of dynamic stresses at the inner boundary, and a propagating shock wave elsewhere, with a decreasing jump discontinuity as the wave-front progresses away from the cavity. It is shown that these new findings were not noted in previous quasi-static solutions, which omitted the effect of the inertia terms in the governing field equations.

N. A. Weil, USA

1089. Bollard, R. J. H., and Zak, A. R., Effect of camber on the thermal stresses and deflections of cantilevered plates, Proc.

Fourth Midwest. Conf. Solid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 1959, 254–269.

Thermal stresses and thermally induced transverse deflections are evaluated for a cambered cantilevered plate. Method is based on Reissner's variational principle, which gives an approximate solution to the biharmonic differential equations.

Reviewer believes that difference between small and large deflection theories is omission of W_x against Z_x and W_y against Z_y, and not omission of both W_x and W_y against Z_y as stated by authors. This means that Eqs. [17a] and [18], and statement following Eq. [18] are incorrect. Curves $H/T = 2$ and $H/T = 4$ in Figs. 6 and 7 are slightly inconsistent, and H/T-curves of Fig. 4 should be numbered in reverse order. Because of the plate aspect ratio 2.0 employed by the authors to illustrate their method, reviewer believes that conclusions should have been confined to this specific aspect ratio value. J. D. Marketos, USA

1090. Hanson, K. L., and Horvay, G., Thermal stresses in a sector prism, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 347–356.

Paper is concerned with the problem of the circular cylinder generating heat. It is suggested that by sectioning the cylinder along diameters the temperature will be unaltered but the numerically greatest stresses may be reduced in magnitude. An approximate solution to the problem is obtained by variational methods.

G. Eason, England

1091. Kunin, N. F., and Kunin, V. N., Influence of stresses on the thermal expansion of the deformed metal (in Russian), *Fiz. Metallov i Metallovedenie* **5**, 1, 173–174, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11903.

Experimental data are furnished on the change in the coefficient of the linear expansion of copper in relation to the value of the normal stress. S. A. Shesterikov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Viscoelasticity

(See also Revs. 1156, 1171, 1206, 1211, 1217, 1251, 1530)

1092. Nettleton, R. E., Thermodynamics of viscoelasticity in liquids, *Physics of Fluids* **2**, 3, 256–263, May–June 1959.

Author shows that by expressing dynamic, tensorial stress-strain relations in accordance with Mooney's model of lattice and spheres of "critically expanded volume," and identifying them with thermodynamic force-flux equations, the Onsager-Casimir reciprocity theorem leads directly to Frenkel's shear-strain separation principle and Maxwell's relaxation equation. Reviewer believes, however, that the strain separation principle is an inherent character of Mooney's liquid model, and thus author's claim of deriving Frenkel and Maxwell equations from general thermodynamic principle is an overstatement.

Shear modulus was computed from hypersound (Debye) wave speed, which in turn was evaluated on theoretical basis from measured value of thermal conductivity. Using this value of shear modulus, and the measured value of coefficient of viscosity, the shear relaxation time was obtained simply as a ratio between these two numbers in accordance with Frenkel's analysis. Results obtained for three different liquid species were in order-of-magnitude agreement with those given by Mooney's formula, derived directly from his theoretical model.

The paper as a whole should be considered a refinement of Frenkel's molecular-kinetic approach, in line with Maxwell's phenomenological relaxation equation.

H. S. Tan, USA

1093. Forster, E. O., and Kolfenbach, J. J., Viscoelastic behavior of greases, *ASLE Trans.* **2**, 1, 13–24, Apr. 1959.

Measurements of the real and imaginary parts of the shear stiffnesses of two greases have been made over frequency ranges from 3×10^{-4} cycles per second to 10 cycles per second and strain ranges from 0 to 80% shearing strains. Grease A had long soap fibers while grease B had soap fibers whose length-to-diameter ratios were less than 10. Two yield stresses were found. For the lowest or bulk yield stress (in the order of 30 dynes/cm^2) the bonds were reformed as soon as broken so that the grease properties remain unchanged. At the higher yield point (in the order of 600 to 700 dynes/cm^2) contacts are broken faster than they can reform and the grease softens. Between these two limits polymer A behaves similarly to a linear polymer in that temperature and time effects can be interchanged. No such relation was found for grease B. These measurements were made with a new plunger-type mechanism that works below resonant frequencies.

W. P. Mason, USA

1094. Lee, E. H., and Radok, J. R. M., Stress analysis in linearly visco-elastic materials (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles 1957; **5**, 321–329.

1095. Hilton, H. H., On the representation of nonlinear creep by a linear viscoelastic model, *J. Aero/Space Sci.* **26**, 5, 311–312 (Readers' Forum), May 1959.

Author compares Baer's empirical creep formula for metals [Proc. 2nd U.S. Nat. Congr. Appl. Mech. p. 569, 1954] with the behavior of a mechanical model consisting of a Kelvin and a Maxwell element in series. He shows that such a model will lead to Baer's formula if the elastic and viscous constants of the Maxwell element are stress-dependent.

H. Kolsky, England

1096. Rimrott, F. P. J., Creep of thick-walled tubes under internal pressure considering large strains, *ASME Trans.* **81 E** (*J. Appl. Mech.*), 2, 271–275, June 1959.

An analytic plastic analysis in terms of true stress-strain relations and von Mises yield criteria was made for the constant pressure loading of thick-walled tubes. Only secondary creep deformations were accounted for. This analysis is only for the effects of large deformations; but for most engineering materials this assumption is justified. The theory has practical applications for the interpretation of pressure tube creep rupture testing and should be used when correlations between tensile data and tube data are sought. A similar analysis would also be required for the creep test data in order to determine the effect of increasing load on the true stress-versus-creep rate relation, $\sigma = f(\dot{\varepsilon})$. The numerical example shows that, for design analysis of strains of less than 5%, the large deflection theory need not be used. Reviewer believes that the author's notation in the sentence between Eqs. (22) and (23) is misleading; otherwise the paper is clear and concise. K. R. Merckx, USA

1097. Nishihara, T., Taira, S., Tanaka, K., and Ohji, K., Effect of stress reduction on secondary creep of mild steel, *Bull. JSME* **2**, 5, 102–107, Feb. 1959.

The transient behavior of 0.14 per cent carbon steel, which appeared by a partial removal of applied stress at the stage of secondary creep, was studied at 450 C. The strain rate after the partial reduction of stress was found smaller than the true steady creep rate for the reduced stress; however it gradually increased with time and appeared to tend to the steady creep rate. It was also found that the higher the applied stress was before the stress reduction, the lower the rate of strain appeared after the reduction at a given strain and the longer period was necessary before the strain rate reached the steady creep rate.

These behaviors were ascertained to be well interpreted by the authors' theory of the plastic deformation of metals at high temperatures.

From authors' summary

1098. Nishihara, T., and Tanaka, K., Creep of mild steel (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles 1957; **8**, 219–226.

1099. Fountain, R. W., and Korchynsky, M., The phenomenon of "negative creep" in alloys, *Trans. Amer. Soc. Metals* **51**, 108–122, 1959.

Measured creep elongation is a sum of true plastic deformation and length changes resulting from the structural instability of alloys. As a special case, the contraction caused by a metallurgical solid-state reaction during creep testing may outweigh the elongation due to the applied stress, and result in a phenomenon termed "negative creep." From the examples of some iron-tungsten and nickel-molybdenum alloys, it is shown that the amount of contraction can be calculated from the known phase relationships and crystallographic data. Experimental results illustrating "negative creep" in these alloys are presented. Under imposed constant strain conditions, the contraction of the alloys may not only retard stress relaxation, but lead to a marked increase in the initially applied stress.

From authors' summary

1100. Carlson, R. L., and Manning, G. K., A summary of compressive-creep characteristics of metal columns at elevated temperatures, WADC TR 57-96 (ASTIA AD 151 114), 57 pp., Apr. 1958.

A summary of an extensive study of the creep buckling of metal columns is presented. The column behavior prior to collapse is described and the column action at the time of buckling is interpreted in terms of stability.

Solutions to creep buckling are discussed. It is concluded that in spite of certain limitations, Shanley's time-dependent tangent-modulus method has several practical advantages over available analytical solutions.

An application of the time-dependent tangent-modulus method to four structural metals indicates that estimates are consistently conservative for small values of column imperfection. Imperfection variations were generally observed to have a very marked effect on the column lifetime.

The possible existence of a lower column-load limit below which time-dependent collapse will not occur is discussed. From a rational consideration of known creep behavior it is concluded that there may be a temperature below which finite lower limits exist and above which the lower limit is zero.

From authors' summary

1101. Oding, I. A., and Tulyakov, G. A., Creep of austenitic steel under a complex state of stress (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 1, 3–10, Jan. 1958.

Thin-walled tubes of alloy (C, 0.09; Mn, 0.78; Si, 0.36; S, 0.010; P, 0.018; Cr, 17.18; Ni, 10.68; Ti, 0.47; heat treatment 30 min at 1100 C and air cooling) were submitted to creep test at 600 C under complex state of stress as follow: $\tau/\sigma = \infty$, 2.0, 1.0, 0.6, 0.5, 0.4, 0.3, 0.

The steady-state creep rate in principal directions was calculated according to expression:

$$v_{1,2} = v_x \pm (\omega_{xy}/2)\{[(\sigma_x/2\tau_{xy})^2 + 1]^{1/2} \mp \sigma_x/2\tau_{xy}\}$$

with condition $v_1 + v_2 + v_3 = 0$.

The values of v_1, v_2, v_3 and $v_i = [2/3(v_1 - v_2)^2 + (v_2 - v_3)^2 + (v_3 - v_1)^2]^{1/2}$ were compared with the ones calculated by expressions:

$$v_i = (A/2)\,3 \exp[(n-1)/2]\,\tau_i \exp(n-1)[(\sigma_1 - \sigma_3) - (\sigma_3 - \sigma_1)] \quad (1, 2, 3) \quad [1]$$

and (by tension)

$$v_i = [a/2(3)^{1/2}] \exp[b(3\tau_i)^{1/2}]/\tau_i\{(\sigma_1 - \sigma_3) - (\sigma_3 - \sigma_1)\} \quad (1, 2, 3) \quad [2]$$

and (by tension and torsion)

$$v_i = (1/2)^{1/2}\, a \exp\{b/2^{1/2}[(\sigma_1 - \sigma_3)^2 + \sigma_3^2 + \sigma_1^2]^{1/2}/[(\sigma_1 - \sigma_3)^2 + \sigma_3^2 + \sigma_1^2]^{1/2}\} \quad (1, 2, 3) \quad [3]$$

where A, n, a and b are constants to determine by creep test under tension:

$$v = A\sigma \exp n, \quad v = ae \exp b\sigma.$$

The steady-state creep rate under complex state of stress may be computed according to Equations (1) (2) or (3) but it is necessary to introduce a correction. Author concludes that under torsion ($\tau/\sigma = \infty$) experimental steady-state creep rate is 2.5 to 3 times larger than the one computed according to Eq. [2]. He believes that the directions of principal stresses are not the same as the principal axes of creep rate. Thus it seems that, under creep, v_1 tends to equal v_2 whereas v_3 tends to zero.

K. Gamski, Belgium

1102. Matveev, S. I., and Trusov, L. P., Influence of temperature fluctuations on resistance to creep (in Russian), Tests for and properties of heat-resistant materials, Moscow, Mashgiz, 1957, 46–60; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 6178.

Authors conclude that when choosing permissible stresses for the limits of creep or for the duration of stability when the temperature is fluctuating a fall in these limits amounting to 10–20% can take place when the steel being tested is pearlite mark 12 MKh and to 15% for an austenite steel.

From authors' summary

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1103. Merckx, K. R., A method for analyzing primary creep data, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 605–610.

Author uses results of creep data for alpha uranium, 100C to 500C, under stresses of 2,000 to 40,000 psi to develop an empirical equation, from relations suggested by other authors, giving creep strain rate $\dot{\varepsilon}$ as a function of creep strain ε and tensile stress σ:

$$\dot{\varepsilon} = \varepsilon^{-m}(\sigma/3G) \exp[k + d(\sigma/2G)]$$

in which G is elastic shear modulus; m, k and d are temperature-dependent parameters. Graphic methods for evaluating temperature functions $T(m, k, d)$ are given in detail.

Provided materials other than alpha uranium that happen to exhibit similar strain-time-temperature behavior in creep are selected, these methods will serve to reduce experimental data to a functional form. The validity of such empirical methods for conditions of stress, time and geometry other than those employed experimentally is not considered by the author.

J. T. Bergen, USA

1104. Findley, W. N., Prediction of stress relaxation from creep tests of plastics, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 521–526.

Data for room-temperature tensile creep of a canvas laminate and a rigid polyvinyl chloride are fitted well by a completely empirical equation relating strain to stress and time. Equation involves 5 parameters and covers range of time of few minutes to several thousand hours. Stress range is limited to 2000 to 5000 psi. This equation, with creep parameters, satisfactorily predicts stress relaxation for similar range of experimental variables. Author shows this agreement is better than that for predictions of theories involving strain-hardening and time-hardening. His

stress-strain time law is proposed as basic function for predicting stress relaxation from creep data. Paper concludes with method for predicting strain recovery from creep, or stress relaxation, experiments. Reviewer notes that this treatment of creep data to predict stress relaxation has been applied only within narrow limits of author's experiments, and is shown to hold only for uniaxial tension; conclusions are thus very restricted in terms of generaeralized stress analysis. J. T. Bergen, USA

1105. Hoff, N. J., Stress distribution in the presence of creep (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles 1957; **8**, 211–218.

Plasticity

(See also Revs. 1083, 1095, 1096, 1146, 1192, 1206, 1250)

1106. Ivlev, D. D., On a single particular solution of ideal plasticity theory in cylindrical coordinates, *Soviet Phys.-Doklady* **3,** 6, 1294–1296, June 1959. (Translation of *Dokladī Akad. Nauk SSSR (N.S.)* **123,** 6, 988–990, Dec. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Problems of ideal plasticity and with negligible elastic strain are considered. Ratios of the plastic incremental strain components are taken to be the same as the ratios of the corresponding deviated stress components. Expressed in cylindrical coordinates, the radial and tangential displacements are functions of radius only and the axial displacement consists of a sum of a function of radius and a function of axial coordinate. Radial body force varies along the radius and the axial body force is constant. Radial variation of temperature is considered. The yielding octahedral shearing stress and thermal expansion coefficient are functions of temperature. Shear stress on a radial plane along axial direction is assumed to vary linearly with radius and that along the tangential direction is assumed to be a function of radius. Equations for the solutions of the stresses and displacements of this type of problem are shown. T. H. Lin, USA

1107. Sato, Y., Experimental relations among pure shear, tension, and compression in plastic domain, *Bull. JSME* **2,** 5, 107–110, Feb. 1959.

Though there are many questions in plasticity, one of the most important subjects is to make clear the relations among pure shear, simple shear, tension and compression. But the relation between pure shear and simple shear is solved not only by theoretical considerations but also by experiments.

Author examines the relations between pure shear, tension and compression in plastic domain with the material that was considered to be isotropic in the virgin state, and obtains the correct experimental relations. These results show that the relation between tension and compression coincides well and pure shear is about 14% higher than tension or compression in all plastic domains. From author's summary

1108. Madejski, J., The dynamical theory of plasticity as a link between the theory of elasticity and the theory of plasticity (in Polish), *Rozprawy Inz.* **6,** 3, 469–481, 1958.

Author discusses pure bending of a rectangular beam under the action of a bending moment M, the physical model of material being such that the equation

$$\frac{\partial \sigma}{\partial t} + \frac{\sigma - \sigma_E}{\theta} = E \frac{\partial \varepsilon}{\partial t}$$

is satisfied. Here σ_E is the elastic limit and θ the relaxation time.

At the instant of applying the moment, we have the elastic state in the beam and then a nonsteady elastic-plastic state. Depending on the value of the moment applied, after an infinite time an elastic-plastic or plastic or indefinite flexural creep will be established in the beam.

For a brittle material, the destruction will appear sooner, the destruction criterion being that of magnitude of plastic deformation. From author's summary

1109. Doshchinskii, G. A., On the theory of elastic plastic deformation (in Russian), *Izv. Tomskogo Politekh. In-ta* **85,** 355–365, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11490.

In order to prepare the equations connecting the components of stresses and deformations in the case of a plain load the following action is proposed. Not only is use to be made of the generalized relationship between the stress and the corresponding deformation taken, for example, from tests for tension of cylindrical samples, but a new independent characteristic is to be brought in—the coefficient of transverse deformation $\mu = \mu(\varepsilon)$ as a function showing the degree of deformation. In such a case the coefficient of three-dimensional deformation would also depend on the degree of deformation, and the mean stress will not be proportional to the spatial expansion. It should be noted that with $\mu \neq 1/2$ the conditions governing a plain load will not be fulfilled.

V. V. Moskvitin
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1110. Hall, A. H., and Saxon, V. L., Analysis of a cantilever beam developing an isoplastic response under impact at the tip, Nat. Res. Counc., Canada, Aero Rep. LR-237, 16 pp., May 1959.

Isoplastic response is defined for a beam as the development of plastic strains simultaneously at all points along the profile fibers. It is stated that two conditions must be satisfield simultaneously, one on the profile shape, and one on the mass distribution. Reviewer believes that the problem is not well set, and that this is the reason why the analysis leads to the rather trivial result that all mass should be concentrated at the tip and that the remainder of the cantilever should be massless. Photographs of four specimens before and after impact are shown.

J. F. Besseling, Holland

1111. Hall, W. J., and Newmark, N. M., Shear deflection of wide-flange steel beams in the plastic range, *Trans. Amer. Soc. Civ. Engrs.* **122,** 666–687, 1957.

This very important paper describes the behavior of continuous steel wide-flange beams under load conditions causing plastic deformations.

The plastic moment capacity for beams under very high shear forces have been investigated. Results indicate that no measurable reduction of the moment capacity was found. The effect of the plastic shear deformation on the beam deflections can be predicted as indicated in this paper.

J. G. Bouwkamp, USA

1112. Zyczkowski, M., Theory of finite deflections of elastic-plastic beams, Proc. 2nd Congr. Theor. Appl. Mech., New Delhi, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1956; 24–32.

Author presents the derivation of the deflection curve of an elastic-plastic beam in the case of large deformations. The following simplifications are introduced: (1) The length of the axis of the beam is assumed to be constant; (2) plane sections remain plane, (3) the loading consists only of concentrated loads; (4) the material of the beam is perfectly plastic; (5) the influence of the shearing stresses in the deflection is neglected; (6) only a rectangular cross section is considered.

Two cases are analyzed: one side and two sides plasticization, and in both cases only the process of loading is considered. The effect of the curvature in the equilibrium equations is introduced;

these equations are substituted in the deflection equation. After suitable changes of variables and simplifications, a Ricatti-type differential equation is obtained in the case of one side plasticization. In the case of two sides plasticization an Abel-type differential equation is obtained. Solution for the two equations is given and the range of validity of the solutions is discussed. Boundary conditions are not analyzed.

C. A. Sciammarella, USA

1113. Akhmerov, A. F., Investigation of processes of bending with tension of components of single curvature (in Russian), *Trudi Kazansk. Aviats. In-ta* no. 36, 49–66, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11533.

This is an investigation of the elastic-plastic deformation of a bar under the action of deflection and tension with evenly applied external loads including: the simultaneous action of bending and tension, tension with subsequent bending, bending with subsequent tension, and the case of successive loading by tension, by bending and then followed by supplementary tension. The diagram of the deformed material of the bar is an approximation of the stepped relationship. Use is made of the equations in the theory of elastic-plastic deformations. It is shown that the sequence of application of the loads has a significant influence on the magnitude of the full and residual deformations. Thus with correspondingly identical magnitudes for the radius of the curvature and the longitudinal deformation, the smallest residual curvature is obtained when bending is followed by subsequent tension.

Yu. A. Rakovshchik

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1114. Owen, M. J., An elastoplastic analysis of a rotating annulus, *J. Franklin Inst.* **267,** 1, 55–68, Jan. 1959.

The problem of an elastoplastic rotating annulus is analyzed completely. The analysis is based on the assumption of plastically incompressible material obeying Hooke's law in the elastic region and yielding according to Tresca's yield criterion. The plastic displacements are found through the flow rule associated with Tresca's yield criterion. The boundary conditions are satisfied for the deformed boundaries. The equations involved are nonlinear, and a solution is found though a perturbation method. The displacement solution resulting from the use of the flow rule is new, and it is shown that in some cases it is important to satisfy the boundary conditions for the deformed boundaries.

A. Phillips, USA

1115. Rasskazov, N. I., Work of a round plate beyond the limit of elasticity (in Russian), *Trudî Mosk. In-ta Khim. Mashinostr.* **14,** 55–79, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11505.

The deflection of an elastic-plastic plate is investigated; the plate is round, supported along its contour and is subjected to an evenly distributed transverse loading. When solving the stated problem the initial assumption is made that the forms of the elastically and the elastically-plastically distorted plates are identical at equal degrees of bending. Poisson's coefficient is taken to be constant in both the elastic as well as the plastic zones of the plate. As conditions of plasticity those of Saint Venant are adopted. As a check on the results obtained by the author, a series of experiments was carried out using steel plates. Satisfactory agreement of the calculated curves with the experimental is recorded for deflections not exceeding half the thickness of the plate.

Yu. R. Lepik

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1116. Olszak, W., and Mróz, Z., Note on the completeness of the elastic-plastic solution to certain boundary value problem for the eccentric ring (in English), *Arch. Mech. Stos.* **10,** 3, 441–444, 1958.

1117. Mikeladze, M. Sh., Theory of plasticity of anisotropic shells (in Russian), Avtoref. Diss. Dokt. Tekhn. Nauk, In-ta Mekh. Akad. Nauk SSSR, Moscow, 1957; *Ref. Zh. Mekh.* no. 5, 1958, 5811.

1118. Beedle, L. S., Plastic strength of steel frames, *Trans. Amer. Soc. Civ. Engrs.* **122,** 1139–1168, 1957.

Paper aims to document applicability of plastic analysis to structural design through examination of test results correlated with applicable theory and in comparison with provisions of current (1957) specifications. Simple step-by-step analysis indicates the utility of the theory but by no means establishes it firmly as a universal tool of structural design. The plastic theory of analysis requires severe testing and exhaustive investigations to push it in line with the older accepted norms of practice. Among these are: the effects of the lowering of the plastic moment due to normal or shear force and the possibilities of fatigue or brittle failure; the possibility of incremental collapse or shakedown; excessive deformations in the collapse stage; and the occurrence of local instabilities before the formation of plastic hinges. Furthermore as has been now recognized, the general plastic theory differs from, and in some instances is even opposed to, the plastic column theory. These vital aspects require careful evaluation before structures can be designed on this new method.

While the paper covers basic data, it does not extend its penetration into the deeper realms pointed out here. In the discussion appended to the paper some light is thrown and salient points raised.

S. K. Ghaswala, India

1119. Yamaguchi, H., Geometrics related to the slip lines in the plastic material with frictional resistance (in Japanese), *Trans. Japan Soc. Civ. Engrs.* no. 61, 1–9, Mar. 1959.

Geometrical properties of slip lines in plastic material with frictional resistance, especially the relations among the lengths measured along each side of a small element composed of slip lines, are studied. The results obtained will be useful for obtaining the numerical solutions of modified Kötter's equations.

Prandtl's theorem is also presented in the modified form together with the discussions on both equi-pressure theorem and Mikhlin's coordinates.

From author's summary

Courtesy, Editorial Committee of the Japan Society of Civil Engineers

1120. Gill, S. S., and Parker, J., Plastic stress-strain relationships—some experiments on the effect of loading path and history, *ASME Trans.* **81**E (*J. Appl. Mech.*), 1, 77–87, Mar. 1959.

Tests have been carried out on thin closed-end tubes of alpha brass subjected to various combinations of torque and internal pressure. The effect of loading, unloading, and reloading along different loading paths has been investigated, including the effect on the shape of the yield surface, and the form of the curve of representative stress and representative strain. The behavior of the material for initial loading suggests that the material is isotropic in the plane of the surface of the tube but is anisotropic in a radial direction. A form of yield criterion and representative stress which correlates these results has been deduced, but the results of the tests for the second loadings of the specimens cannot be correlated in terms of a nested set of similar yield surfaces. The evidence for or against the existence of corners or pointed vertices on the yield surface is inconclusive.

From authors' summary

1121. Deriagin, G. A., Some improvements in the measurement of deformations for the determination of residual stresses in thin-walled rings (tubes), *Indust. Lab.* **24,** 2, 219–221, Mar. 1959.

(Translation of *Zavod. Lab., USSR* **24**, 2, 206–208, Feb. 1958 by Instrument Society of America, Pittsburgh, Pa.)

1122. Koistinen, D. P., The distribution of residual stresses in carburized cases and their origin, *Trans. Amer. Soc. Metals* **50**, 227-238, 1958.

Rods, Beams and Strings

(See also Revs. 1042, 1085, 1110, 1112, 1113, 1149, 1152, 1158, 1164, 1165, 1180, 1228, 1241)

1123. Engel, E., Bending stresses of a rope on an elastically lined roller (in German), *Öst. Ing.-Arch.* **11**, 3, 238–243, Nov. 1957.

An approximate method is presented for the determination of the load distribution (assumed to be parabolic) between a rope and an elastically lined roller. The numerical results are sufficiently accurate for practical purposes in view of the uncertainties and idealization inherent in a more rigorous analysis. As a justification, two numerical examples are presented and compared with an exact theory due to Czitaryl. Agreement is satisfactory for practical purposes.

F. V. Pohle, USA

1124. Shanley, F. R., On the strength of fine wires, Rand Corp. RM-2011 (ASTIA AD 144 288), 19 pp., Sept. 1957.

A theory for the exceptionally high tensile strength of very fine wires (or fibers) is developed on the basis that the "core" material slips at nominal stress, while the "skin" material must develop a very high tensile stress in order to completely disrupt the atomic bonds. The resulting equation gives excellent correlation with test data. The physical significance of the theory is discussed, as applied to glass and metal fibers. Suggestions for further study and tests are included.

From author's summary

1125. Peterson, J. P., and Bruce, W. E., Jr., Investigation of the structural behavior and maximum bending strength of six multiweb beams with three types of webs, NASA Memo 5-3-59L, 28 pp., May 1959.

The results of bending tests on six multiweb beams of optimum weight-strength design are presented. The internal structure of the beams consisted of various combinations of two types of full-depth solid webs and a post-stringer web. The observed structural behavior, buckling load, and failing load of the beams are compared with results obtained by the use of existing methods of analysis and found to be quite predictable.

From authors' summary

1126. Amenzade, Yu. A., Bending of the prismatic beam weakened by a circular cavity (in Azerb.), *Trudï Azerb. Industr. In-ta* no. 14, 107–123, 1956; *Ref. Zh. Mekh.* no. 1, 1958. Rev. 958.

1127. Frame, J. S., A continuous fraction solution of the Karman tube bending problem (in German), *Öst. Ing.-Arch.* **12**, 1/2, 95–101, Nov. 1958.

By using Karman's theory, author expresses with the aid of a continuous fraction the coefficient $\varkappa < 1$ with which the bending moment is decreased in a curved thin-walled tube with circular cross section subjected to the action of an angular deformation (a variation of the angle between the end cross sections).

The ratio $\varkappa/b$ is calculated, where $b = R\,\delta/(r^2\sqrt{3})$, R being the curvature radius of the tube axis, δ its thickness and r the cross section mean radius. For small values of b, author gives a series development without including a proof of its convergence.

P. P. Teodorescu, Roumania

1128. Andronov, V. P., Local stresses in recessed shafts and axles (in Russian), *Trudï Gor'kovsk. Politekh. In-ta* **13**, 4, 5–21, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11808.

Results are given for the investigation on the distribution of stresses within the limits of elasticity during the deflection and torsion of shafts with recessed surfaces; the investigation was carried out on models (made from a magnesium alloy) having diameters of 120–200 mm; the ratio of the radius of the recessed shaft to the diameter fluctuated within the limits of 0.1 to 0.5, the ratio of the large diameter to the small, within the limits of 1.2 to 2. Curves were drawn for the concentration coefficients. An analytical investigation is also given on the distribution of stresses, the basis of which is the method of out-of-plane sections developed by A. V. Verkhovskii [*Trudï Gor'kovsk. Politekhn. In-ta* **9**, no. 1, 1951]. The divergence between the experimental and theoretical values for the coefficients of concentration amounted to 8 to 9%.

V. P. Kogaev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1129. Palm, J., and Thomas, K., Analysis of curved beam springs (in German), *Z VDI* **101**, 8, 301–308, Mar. 1959.

Castigliano's theorem is applied to curved beam springs, bent in their own plane, of various types used in switches and similar devices. Results are compared with experiment. Sample calculations and discussion of error sources are included.

G. A. Nothmann, USA

Plates, Shells and Membranes

(See also Revs. 1083, 1086, 1089, 1114, 1117, 1154, 1155, 1163, 1164, 1165, 1171, 1174, 1230)

1130. Jurney, W. H., Displacements and stresses of a laterally loaded semicircular plate with clamped edges, *ASME Trans.* **81E** (*J. Appl. Mech.*), 2, 224–226 (Brief Notes), June 1959.

Author uses Mitchell's solution, in finite form, for the problem of a point-load on a circular plate having clamped edges and Poisson's solution, also in finite form, for a uniformly distributed load on such a plate. Conditions of symmetry ensure zero slope along a diameter, and a combination of the Mitchell and Poisson solutions, in such a way as to produce zero deflections at all points along a diameter, leads to a solution for the semicircular plate with clamped edges carrying a uniformly distributed load. The combination of solutions provides an integral equation which is solved by numerical integration based on the trapezoidal rule. Tables are given for the calculation of moment and shear and author discusses, as an example, the design of a semicircular floor slab.

R. T. Severn, England

1131. Nash, W. A., and Cooley, I. D., Large deflections of a clamped elliptical plate subjected to uniform pressure, *ASME Trans.* **81 E** (*J. Appl. Mech.*), 2, 291–293 (Brief Notes), June 1959.

The nonlinear large deflections are calculated by the method of successive approximations based upon the smallness of central deflection. Results of the analysis are shown to be in excellent agreement with experimental data obtained from test of an aluminum plate.

From authors' summary by G. Sonntag, Germany

1132. Morozov, N. F., The uniqueness of the symmetrical solution in the problem of the large deflection of a symmetrically loaded circular plate, *Soviet Phys.-Doklady* **3**, 6, 1275–1278, June 1959. (Translation of *Dokladï Akad. Nauk SSSR (N.S.)* **123**, 3, 417–419, Nov. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Author proves proposition in title through the Hildebrand-Graves theorem by showing that the conditions for the application of the

latter are fulfilled in the case of the system of ordinary differential equations which arises from von Karman's plate equations as applied to symmetrically loaded circular plates. The problem is first solved for the case of a symmetrically loaded clamped plate and then it is indicated how similar proofs for other types of boundary conditions can be carried out analogously.

H. C. Reggini, Argentina

1133. Chen, M. M., and Foss, K. A., On some solutions for large deflections of heated strips and plates, Proc. Fourth Midwest. Conf. Solid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 1959, 207–232.

Solution to von Karman's large deflection equations for curved plates is given, using the following approximate methods: (a) Reissner's variation principle; (b) thermal buckling mode; (c) minimum potential energy. All these methods are compared numerically with the exact solution for a clamped-clamped flat strip to give an indication of the accuracy of these methods when applied to finite plates. For a highly loaded flat strip and heated at its critical temperature, or unheated, application of Reissner's principle gave the best results; thermal-buckling-mode method gave very good results. The latter method also gives good results for very small loading (region of Euler-type buckling).

J. D. Marketos, USA

1134. Mednikov, I. A., Extending the field of application of some tables for the calculation of plates (in Russian), *Trudi Mosk. Avtomob.-dor. In-ta* no. 20, 149–152, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11455.

Formulas are advanced with the aid of which (the values of the forces acting on the plate, calculated for two different values of Poisson's coefficient, are taken from tables) forces acting on the plate can be computed for any value of Poisson's coefficient.

B. G. Rekach

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1135. Hamada, M., Stress distribution in a rectangular plate subject to forces acting in its plane, *Bull. JSME* **1,** 4, 367–374, Nov. 1958.

The problem of stress distribution in a rectangular plate subject to forces acting in its plane is solved by using the method of strain energy. For the Airy function, the double Fourier cosine series is used and the coefficients are determined through Lagrange's multiplier method by considering the boundary conditions as constrained conditions. By using a finite number of terms, method is applied to the case of square and rectangular plates subject to two concentrated forces at the center of the opposite edges, to the case of rectangular plates subject to the distributed load of the form $(1 - \cos 2\pi x)/2$, as well as to the case of plates subject to uniformly distributed loads. From these examples it is shown that the use of eight or ten unknowns will give satisfactorily good results as far as the stress values in the interior of the plate are concerned.

A. L. Petre, Roumania

1136. Kushul', M. Ya., On bending of cantilevered plates, defined by piecewise smooth curves (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 10, 133–138, Oct. 1958.

A cantilever plate with free edge formed by a piecewise smooth curve is investigated. Assumed loading: the load $q(x,y)$ distributed over the upper surface of the plate, the bending and twisting moments G_ν and $G_{\nu t}$, respectively, and the shearing force N_ν along the free edge.

Applying the variational formulas of Kirchhoff and Lagrange, author completed the formulation of this problem due to Kirchhoff. He shows that the problem is fully defined by the differential equation

$$\nabla^2 \nabla^2 w = q/D$$

and the boundary conditions

$$w = w_x = 0 \quad \text{along the built-in edge}$$

$$M_\nu = G_\nu \quad \text{along the free edge}$$

$$V_\nu = N_\nu - \partial G_{\nu t}/\partial s \quad \text{along the free edge}$$

and

$$M_{\nu t}(s_j - 0) - M_{\nu t}(s_j + 0) = G_{\nu t}(s_j - 0) - G_{\nu t}(s_j + 0)$$

in every angle point.

$$G_{\nu t}(s_j - 0) \text{ and } G_{\nu t}(s_j + 0)$$

represent the values of the twisting moments from the right and left respectively. M_ν and V_ν are the corresponding values of the internal forces (bending moment and shearing force).

The solution of this problem is sought by the variational method.

A numerical example—the cantilever plate in the form of the isosceles triangle—solved by the method of Ritz is indicated.

V. Kovarik, Czechoslovakia

1137. Tarabasov, N. D., The stressed state of a composite plate of elliptical form (in Russian), *Naucbn. Trudi Mosk. Poligr. In-ta* no. 5/6, 89–107, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11399.

The plane problem is investigated in the theory of elasticity of an elliptical plate with one or several circular holes into which, under tension, are inserted disks of the same thickness as the plate and of the same material. This problem, as was shown by D. I. Sherman [*Dokladi Akad. Nauk SSSR* **27,** no. 9, 1940], merges with the usual problem in the theory of elasticity of a plate without holes. The first basic problem for an elliptical region is solved in series by means of conformal transformation of the exterior of the ellipse to the exterior of the surroundings. Numerical examples are given.

V. I. Mossakovskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1138. Frederick, D., Thick rectangular plates on an elastic foundation, *Trans. Amer. Soc. Civ. Engrs.* **122,** 1069–1087, 1957.

Author summarizes Reissner's theory of shear deformation of isotropic elastic plates. Various boundary conditions are discussed. Modification by Naghdi and Rowley to include effect of elastic foundation supporting plate is introduced. Solutions are given for four problems: (1) Simply supported rectangular plate with arbitrary distributed normal load—solution of Navier type. (2) Rectangular plate with two opposite edges simply supported and other edges subjected to arbitrary boundary conditions consistent with Reissner theory—solution of Levy type. (3) Infinite plate resting on elastic foundation and loaded normally by uniform line load. (4) Infinite strip with parallel clamped edges loaded by uniform antiparallel shears applied laterally to faces.

H. L. Langhaar, USA

1139. Riley, W. F., Durelli, A. J., and Theocaris, P. S., Further stress studies on a square plate with a pressurized central circular hole, Proc. Fourth Midwest. Conf. Solid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 1959, 91–107.

Book—1140. Chronowicz, A., The design of shells, New York, Frederick Ungar Publishing Co., 1959, xix + 202 pp. $8.50.

Title of the book is incomplete in that only cylindrical shells are considered; Subtitle is "A practical approach." Chapters are: 1: Introduction. Membrane theory. 2: The differential equation of shells. 3: Symmetrical problems. 4: The end shell. 5: The north light shell. 6: Shells with prestressed boundary beams. 7: Anisotropic shells. 8: Plate approximations. 9: Balanced shear method. 10: Construction notes. 11: End frames. 12: Arched

beams. 13: The application of column analogy to the design of shells. There is a short bibliography and index. Chapters 11 and 12 are associated with shell design only indirectly. Reviewer believes that, with the exception of Chapter 13, both as an introduction to analysis and as a practical approach, the book falls short of these stated goals through a lack of clarity of presentation, which apparently has its source in a lamentable lack of understanding of the subject matter (consider for example the following passage from the preface, p. ix: "The popular differential equation of Finsterwalder is selected as the basis of the analytical solution, mainly because of its simplicity and yet sufficient accuracy. Beginners find it easier to understand because it is solved by means of boundary conditions based on the natural stresses in the shell and not on groups of differential coefficients without direct physical meaning.") At least two earlier books meant for a similar audience are far superior: Gibson & Cooper, "The design of cylindrical shell roofs," London, Spon, 1954; and Rüdiger & Urban, "Circular cylindrical shells," Leipzig, Teubner, 1955.

S. J. Medwadowski, USA

1141. Vorovich, I. I., Certain questions on the large deformation stability of shells, *Soviet Phys.-Doklady* **3,** 5, 1032–1035, May 1959. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **122,** 1, 37–40, Sept. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Given a nonlinear boundary-value problem (NBVP) for the buckling of a shell and the corresponding linear boundary-value problem (LBVP), the following theorems are proved: 1. The points of the spectrum of the NBVP are distributed to the right of a certain point $\lambda_n < \infty$, where the arbitrary half interval $\lambda_n \leq \lambda < \lambda_n + \varepsilon$ ($\varepsilon > 0$ is an arbitrarily small number) contains at least one point of the spectrum. In addition the entire half line $\lambda > \lambda_e$ belongs to the spectrum of the NBVP, where λ_e is lambda of Euler. 2. There exists a number λ_s such that for all $\lambda > \lambda_s$ the shell, in addition to a purely membrane form of equilibrium, possesses at least one bending form of equilibrium with a lower level of potential energy. 3. For plates $\lambda_n = \lambda_s = \lambda_e$. 4. If the potential energy I of the system is written according to Kh. M. Mushtari as the sum of 3 functionals of order k which are homogeneous with respect to the displacement w and if an element χ exists, belonging to the proper subspace λ_e and such that the second functional $I^{(3)}(\chi) \neq 0$, then there occurs the strict inequality $\lambda_s < \lambda_e$. In this case the stability problem cannot be solved by means of the LBVP. 5. In order for the point λ to be a point of bifurcation of the NBVP, it is necessary and sufficient for λ to be an eigenvalue of the LBVP. 6. To every level of potential energy I of a buckled plate there corresponds a countable number of functions w_n of the NBVP. In this case all of the corresponding eigenvalues $\lambda_n > \lambda_e$ and $\lambda_n \longrightarrow \infty$ for $n \longrightarrow \infty$.

M. G. Salvadori, USA

1142. Vorovich, I. I., Defects of direct methods in the nonlinear theory of shells, *Soviet Phys.-Doklady* **3,** 5, 1036–1039, May 1959. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **122,** 2, 196–200, Sept. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Two methods of successive approximations for the solution of the nonlinear large deformation equations of shell theory have been given by P. F. Papkovich and Kh. M. Mushtari. Author derives five theorems that prove the convergence of these two methods under given conditions.

M. G. Salvadori, USA

1143. Donnell, L. H., Shell theory, Proc. Fourth Midwest. Conf. Solid Mech., Austin, Texas, Sept. 1959; Austin, Texas, Univ. Press, 1959, 1–17.

This paper constitutes one of several invited lectures given at the Fourth Midwest Conference on Solid Mechanics. A review of beam theory is offered for the cases of both small and large deflections and analogies are drawn between beam behavior and deflections of plates and shells. The nonlinear theory of plates due to von Karman is surveyed and the case of an initially imperfect plate discussed. The small-deflection theory for thin cylindrical shells originally presented by Donnell in 1933 and applied to the case of torsional buckling is considered in some detail. Next, finite deflection theories due to Donnell (1934) as well as von Karman and Tsien (1941) and Donnell and Wan (1950) are briefly reviewed and the important role of initial imperfections discussed.

Recent work of the author concerning the buckling of initially imperfect spherical shells subject to uniform external pressure is presented for the first time. The results establish the fact that use of shallow shell theory is justified and also that the case considered is relatively insensitive to defects. Lastly, the effect of transverse shear is considered and the author's work on thick plate theory reviewed. Since flexure is little affected by curvature it is suggested that the same logic can be applied to the analysis of a cylindrical shell when a consideration of transverse shear strains is desired.

W. A. Nash, USA

1144. Aksel'rad, E. L., On the thermal deformations of heterogeneous shells (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 8, 48–52, Aug. 1958.

A solution is obtained for a shell of arbitrarily varying elastic properties and temperature expansion coefficient for that load distribution which would cause the same deformations as a given temperature distribution. As the problem of deformation of an externally loaded shell having varying elastic properties across its thickness can be reduced to the corresponding problem for a homogeneous shell, so the temperature problem for a shell, heterogeneous across its thickness only, is reduced to a statical problem for a homogeneous shell.

From author's summary by J. Solvey, Australia

1145. Rzhanitsyn, A. R., The theory of sloping shells without moment (in Russian), Calculations for extensive constructions, no. 3; Moscow, Gos. Izd-vo Lit. po Str-vu i Arkhitekt., 1955, 285–307; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11424.

A shell is examined, the central surface of which is given by the equation $z = f(x,y)$. The condition of slope is included in the requirement that the individual derivations of z shall be small. The shells are computed by the momentless theory and, obviously, it is necessary for the individual derivatives of z to be delimited not only from the top but also from the bottom to retain their absolute value, because the boundary state of a sloping shell is a plate, to which the momentless theory, of course, is inapplicable. This question of delimitation is not touched on in the paper. Another indication of the applicability of the momentless theory is investigated in detail; this is the requirement of geometrical unalterability (absence of infinitely small deflections) of the central surface at assigned boundary conditions. It is demonstrated that for sloping shells, the central surfaces of which are surfaces of the second order, both the momentless equations of equilibrium as well as the equations determining the infinitely small deflections can be brought to an equation having the form of

$$\frac{dp}{dx} = \frac{dq}{dy}, \quad \frac{dp}{dy} = \pm \frac{dq}{dx} \qquad (*)$$

(the upper sign for shells of positive curvature, the lower for shells of negative curvature). With the help of these equations it is established which of the edges of the shell shall be clamped to guarantee its geometrical unalterability. In particular, it is shown that a hyperbolic shell with a rectangular surface, clamped along the edges of one of the transpositions u, v or w will not be stiff if the relations of the dimensions of the rectangle are expressed by an arbitrary irrational fraction with an uneven numerator and denominator. Convergent results were obtained in the papers by A. M. Sokolov [*Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 5, 85–101, 1955] and V. Z. Vlasov [*Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk*

no. 5, 55–84, 1955]. The paper finishes with some examples of calculations for a shell having the form of a sloping elliptical paraboloid; in these examples the system (*) is brought to Laplace's equation and is integrated with the aid of the differential calculus.

A. L. Gol'denveiser

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1146. Khazaliya, G. I., An investigation of spherical reinforced concrete shells beyond the elastic limit and the determination of their load-carrying capacity (in Russian), Avtoref. Diss. Kand. Tekhn. Nauk, Akad. Str-va i Arkhitekt. SSSR, Tbilissi, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2313.

1147. DeSchwarz, M. J., Questions of convergence in the calculation of circular cylindrical shells (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6**, 272–279.

1148. Zarif'yan, A. Z., Verification of the stability of the plane form of deflection of thin-walled tubes when loaded transversely and under eccentric compression (in Russian), *Trudi Novocherk. Politekhn. In-ta*, **70/84**, 135–158, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11713.

This is an investigation of single-span hinge-clamped beams with open symmetrical profiles, bending in the plane of maximum stiffness, taking into account the buckling of the beam in this plane. The consideration of this influence leads to the replacement of the minimum stiffness of the beam by the given stiffness. It is shown that in so doing the calculable values of the critical loads in some cases increase significantly (up to 30%). Equations are obtained for the calculations of the critical loads by adopting the method developed by Bubkin-Galerkin in the first approximation. Curves and tables are produced to show the critical stresses with different correlations of stiffness in the principal planes.

Yu. D. Kopeikin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Buckling

(See also Revs. 1133, 1141, 1143, 1148, 1163, 1224)

1149. Appl, F. C., and Zorowski, C. F., Upper and lower bounds for special eigenvalues, *ASME Trans.* **81**E (*J. Appl. Mech.*), 2, 246–250, June 1959.

Authors apply Collatz's enclosure theorem in its simplest form to the two problems of the buckling of a pin-ended column with variable moment of inertia of the form $I_0(1 + ax^2)$ and $I_0(1 + ax + bx^2)$; exact solutions in the former case are known and compared with the approximate values; method is then applied to the second case for $b = -0.4(0.2)0.4$ and $a = 0(0.2)1$ and results are given for the lowest buckling load. Maximum errors are almost always a small fraction of one per cent.

Method assumes a buckling mode in the form of a polynomial of degree n (equal to 11 in the above examples) which is made to satisfy the boundary conditions and additional conditions on an "error" function. Thus n algebraic equations in n unknowns must be solved (as a function of a given parameter), and upper and lower bounds are determined by the aid of an electronic computer. Authors assert that the method is well adapted to automatic machine calculations; in the view of the lengthy arithmetic (involving only algebra and differentiation) this would seem to be an essential tool in the applications. However, no additional cases are presented and no alternative procedures, as given in the text by Collatz, are discussed or compared with the present method.

F. V. Pohle, USA

1150. Laird, W. M., and Bryson, A. M., An analysis of continuous beam-columns with uniformly distributed axial load, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 387–392.

An analytical method for determining deflection, bending moment, and stability of single-span beam columns with uniformly distributed axial load that deflects with the column was developed previously by Tyler and Rouleau [AMR **8** (1955), Rev. 3678]. The present paper extends this solution to members continuous over three or more supports. A three-moment equation is developed for cases where the lateral load distribution is a continuous function and the uniformly distributed axial load and the section properties remain constant in each span. Formulas for the three-moment coefficients are given in terms of Airy integral functions. Numerical values of the coefficients are tabulated for the case of zero concentrated end load.

J. W. Clark, USA

1151. Nevedrov, A. T., Calculations for the deformation and stability of rod assemblies (in Russian), *Trudi Novocherk. Politekhn. In-ta* **70/84**, 121–133, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11689.

Calculations are given for the deformation of a system of intersecting beams. The beams may have stepped sections and may be loaded by transverse and longitudinal forces. The calculations proceed by the combination method. The basic system of the method of displacements is adopted in the form of the sum-total action of the compressed-deflected continuous beams on the nonpliable supports. In deriving the canonical equations use is made of the method of momentary focal relations. The calculation of longitudinal bending is made easier by the application of graphical methods. A comparison was made of the calculations carried out by the undeformed and the deformed schemes. The advantages of the combination method in comparison with both the method of forces and the method of displacement are pointed out.

Yu.D. Kopeikin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1152. Kondrat'ev, A. S., Oscillatory properties of the equilibrium forms of a beam column, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **22**, 4, 754–757, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

A bar of variable rigidity under the action of an axial load $Pf(x)$ is considered. The deflection $y(x)$ of such a bar satisfies the homogeneous integral equation

$$y'(x) = P\int_0^l K_{11}(x, s)y'(s)d\sigma(s) \quad (d\sigma(s) = f(s)ds)$$

where $K(x, s)$ is the influence function of the bar, l its length, and $K_{11}(x, s) = \partial^2 K/\partial x \partial s$.

It is known that the kernel of this equation is positive definite. Consequently all of its eigenvalues are positive. These values P_k are the "critical forces" of the bar, while the eigenfunctions $y_k'(x) = z_k(x)$ determine the possible equilibrium forms corresponding to those "critical forces."

In this paper it is shown that:

(1) In the cases when (a) one end of the bar is pinjointed, while the other end is free and (b) one end is rigidly built in, while the other is pinjointed, the function $K_{11}(x, s)$ and hence the functions $z_k(x)$ are oscillatory.

(2) When the bar is hinged at both ends and the notation $P^\delta = P + \delta$ with $\delta < P_1$ is introduced, the kernel

$$Q(x, s) = \sqrt{f(x)f(s)}\,K_{11}(x, s) + \frac{1}{\delta l\sqrt{f(x)f(s)}}$$

becomes oscillatory in the case of sufficiently small δ.

(3) Same oscillatory properties as in the case of a bar with hinged ends can be established for bars with following end conditions: (a) clamped-hinged, (b) clamped-clamped, and (c) clamped-elastically built-in. G. C. K. Yeh, USA

1153. Abbassi, M. M., Buckling of struts of variable bending rigidity, *J. Appl. Mech.* **25,** 4, 537–540, Dec. 1958.

Author shows that an approximation to the solution of the moment equilibrium differential equation for the buckling of simply supported columns of arbitrary section with general longitudinal loading can be represented by a linear combination of the sine and cosine of a function of the spanwise coordinate. This function is the indefinite integral of the square root of the ratio of load to bending stiffness; that is $(P/EI)^{1/2}$. Application of the approximation is made to the buckling of the strut of variable cross section and the strut under variable axial loading. It is shown that for the examples chosen simple algebraic expressions of good accuracy are obtained for the buckling loads.

J. E. Duberg, USA

1154. Keller, H. B., and Reiss, E. L., Non-linear bending and buckling of circular plates, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 375–385.

Iterative solutions of finite difference approximations of the nonlinear von Karman plate equations are presented. Results are obtained for circular plates under a variety of boundary conditions subjected to either uniform lateral pressure or uniform edge thrust.

The solution, carried out numerically on the AEC UNIVAC at New York University, yields a complete description of stresses and deflections for an apparently unlimited range of load parameters. In addition, boundary-layer phenomena are discussed. For computing purposes, this iterative method proves to be superior to the previously used power series method and may be applicable to other nonlinear problems.

From authors' summary by J. Solvey, Australia

1155. Voitsekhovskaia, K. F., The stability of cylindrical shells from the standpoint of the mathematical theory of elasticity, *Soviet Phys.-Doklady* **3,** 6, 1279–1282, June 1959. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **123,** 4, 623–626, Dec. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

The axially symmetric form of instability of a compressed cylindrical shell is examined on the basis of the general elasticity equations for axially symmetric stresses. The biharmonic stress function is expressed in terms of Bessel and Neumann functions. The compressive stress for the shell in the buckled state to satisfy the boundary conditions gives the critical stress. This critical compressive stress reduces to that of thin shell theory by Timoshenko as the shell thickness approaches zero.

T. H. Lin, USA

1156. Mathauser, E. E., and Berkovits, A., Determination of static strength and creep buckling of unstiffened circular cylinders subjected to bending at elevated temperatures, NASA Memo 6-14-59L, 18 pp., June 1959.

A method based on a semi-empirical procedure is presented for predicting static strength and creep buckling of unstiffened circular cylinders subjected to pure bending at elevated temperatures. The method is applicable to cylinders that are loaded into the inelastic stress range prior to buckling and fail in a local mode. The predicted bending moments associated with static strength and creep buckling are compared with experimental data (taken from NACA RM 57E17) obtained from tests at 500 F on 5052-O aluminum-alloy cylinders with radius-thickness ratios ranging from 125 to 250.

From authors' summary by R. M. Evan-Iwanowski, USA

1157. Singer, J., Thermal buckling of solid wings of arbitrary aspect ratio, *J. Aero/Space Sci.* **25,** 9, 573–580, 590, Sept. 1958.

Paper summarizes results of thermal buckling analyses of solid wings for edge-free conditions by Rayleigh-Ritz method. It shows that: (1) The simple torsional distortion is, in general, predominant in the displacement of the wing when it buckles under thermal stress, if end effect is neglected. (2) For low-aspect-ratio wings, buckling critical temperature can be determined by including an "end effect factor," which is shown to vary very little with the temperature distribution or the airfoil cross-section shape.

H. Lin, USA

Vibrations of Solids

(See also Revs. 1042, 1056, 1059, 1133, 1163, 1164, 1175, 1488, 1505)

1158. Terazawa, K., and Matsuura, Y., Transverse vibration of higher frequencies of beams of uniform cross section, taking into account the effect of shear, *Technol. Rep. Osaka Univ.* **8,** 281–297, Oct. 1958.

Paper offers a clear derivation of the equation for transverse vibrations of beams originally due to Timoshenko. Chief value resides in the numerical examples which show clearly the relative effects of taking into account the shear and rotary inertia of the cross section. M. J. P. Musgrave, England

1159. Karyakin, N. I., The torsional bending vibrations of thin-walled bars (in Russian), *Trudi Belorussk. In-ta Inzh. Zh.-d. Transp.* no. 1, 147–151, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2112.

1160. Safronov, Yu. V., Free torsional vibrations of shafts of variable section (in Russian), *Trudi Rostovsk. N/D. In-ta. S.-kh. Mashinostr.* no. 8, 309–321, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11482.

The frequency equation is obtained for the free torsional vibrations for a stepped shaft consisting of an arbitrary number of portions. At the boundaries of the portions the transverse sections of the shaft and the linear moment of inertia are constant. The more frequently occurring cases of different end conditions are investigated: the ends of the shaft are rigidly clamped; the ends are free; at one end of the shaft—an elastic seal, at the other end—a rigid one; one end of the shaft is elastically sealed, the other is free or carries a concentrated mass; one end is free, the other sealed. A. F. Gurov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1161. Yakushev, I. S., A practical method of calculating the natural oscillation frequencies of beam and frame structures (in Russian), *Sb. Statei Vses. Zaochn. Politekhn. In-ta* no. 17, 93–104, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7952.

1162. Stokey, W. F., and Zorowski, C. F., Normal vibrations of a uniform plate carrying any number of finite masses, *ASME Trans.* **81E** (*J. Appl. Mech.*), 2, 210–216, June 1959.

Lagrangian method is used in deriving normal mode expressions for equations of motion of simply supported plate. Translatory and rotary kinetic energy of attached masses are added to kinetic energy of plate to obtain total kinetic energy. Frequency equation derived for n masses contains a doubly infinite sum and is of 3 nth order. For no more than two masses of moderate size, experiment indicates that use of only first four unperturbed eigenfunctions gives fundamental frequency within 16%. Calculations involve iteration of frequency matrix on digital computer. Experi-

mental errors from constraints of supporting knife edges and mass attachment account for part of discrepancy.

V. Salmon, USA

1163. Shulman, Y., On the vibration of thermally stressed plates, Proc. Fourth Midwest. Conf. Solid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 1959, 233–253.

Vibrational behavior of a thermally stressed thin rectangular plate is examined. The plate, insulated around all four edges, is simply supported along its two short edges. Support conditions along the longitudinal edges are parametrically described. A quasisteady temperature condition is assumed. Solving von Karman's compatibility and equilibrium equations results in lateral deflection equation for the plate in terms of vibration mode and buckling mode eigenvalues.

Several conclusions of interest are: (1) Buckling mode and vibration mode are identical under certain longitudinal edge support conditions. (2) Vibration frequencies decrease with temperature rise at the prebuckling range. (3) Rotational restraint of longitudinal edges raises critical temperature, whereas lateral restraint of same edges lowers critical temperature. (4) Vibration modes in the postbuckling range are related with buckling modes in the prebuckling range.

J. D. Marketos, USA

1164. Beesack, P. R., Isoperimetric inequalities for the nonhomogeneous clamped rod and plate, *J. Math. Mech.* **8,** 4, 471–482, July 1959.

Certain theorems are proved for limits to the extreme natural frequencies of the mechanical systems described in the title. These results are still further examples of a class of inequalities that occur in mathematical physics and are known as isoperimetric inequalities [see G. Pólya and G. Szegö, "Isoperimetric inequalities in mathematical physics," Princeton University Press, 1951].

H. G. Hopkins, England

1165. Lane, F., and Slutsky, S., A shell analysis of compressor blade vibrations, Proc. Fourth Midwest. Conf. Solid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 1959, 53–73.

Blade vibrations are analyzed in terms of the differential geometry of the blade middle surface, considering the blade as a shell structure. The effects of rotation and aerodynamic apparent mass, as well as the self-excited air forces, have been considered but are not treated in this paper. The entire development proceeding from the prescription of initial blade geometry to the resulting final mode shape and frequency is programmed for execution upon the IBM 704 digital computer. Good agreement is found between the computed frequencies and those obtainable from a bench test. Stress distributions associated with the mode shapes are derived and computerized for rapid determination. The shell theoretical approaches used make feasible the prediction of chordwise deformations which cannot possibly be predicted by the conventional beam theory.

D. Kececioglu, USA

1166. Fedenko, G. I., Calculations for the vibrations of a ship's sloping shells when taking into account their curvature and the pliability of the assembly (in Russian), *Sudostroenie* no. 9, 12–16, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11461.

Results are given of the solution of the problem of the free deflection vibrations of a ship's sloping, open, round cylindrical shell, reinforced along its contour by stiff or elastic ribs. The solution is founded on the general theory of sloping shells. Some particular cases are investigated: (1) the shell is reinforced along the whole of the contour with stiff ribbing; (2) the shell, along its linear edges, is reinforced with stiff ribs; along its curvilinear edges, with elastic ribs; and (3) the shell along the linear and along one of the curvilinear edges is reinforced by stiff ribs and along the other curvilinear edge with elastic ribs. The transcendental frequency equations obtained are solved by the graphical method. An approximate evaluation is made of the influence of the attached mass of water on the frequency; this proved to be very significant. Examples are furnished.

B. I. Slepov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1167. Vaserman, E. B., Three-dimensional vibrations of a round arch under variable behavior of the load in the process of deformation (in Russian), *Ucb. Zap. Latv. In-ta* **13,** 7–31, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11470.

An investigation is made of the natural vibrations and the stability of a plane form of deflection of round arches, evenly loaded with radially distributed loads. The problem is solved with the help of the usual assumptions for the theory of small elastic deformations (small dimensions of the arch by comparison with the radius of curvature; one of the principal axes of inertia in the plane of the initial curvature; disregard of the influence of the rotational forces of inertia and of the action of the transverse force; the arch's axis not being capable of elongation; small displacements and deformations). Three cases are examined of the behavior of the load in the process of vibration: (1) the load remains normal to the axis of the arch, (2) the load is parallel to its initial direction, (3) the load remains directed toward the center of the initial axis of the arch. The problem leads to a differential equation of the sixth order with constant coefficients relative to the displacements perpendicular to the plane of the arch. A precise solution was obtained for the natural frequencies in the cases of symmetrical and antisymmetrical forms of vibration. The critical loads for static stability were obtained as a particular case of the problem in dynamics with a vibration frequency equal to zero. A simpler solution was obtained by Galerkin's method after a special selection of the approximation function. Comparisons are given between the results of the precise and approximate solutions and the solutions by Brown [F. H. Brown, *J. Franklin Inst.* **217,** 1, 41–48, 1934] and by Federhofer [K. Federhofer, *Sitzber. Akad. Wiss. Wien Abt.* **145,** 1, 29–56, 1936] obtained by Rayleigh's method. A series of critical remarks and recommendations are put forward in connection with A. P. Morgaevskii's paper [*Inzbener. Sb.* **22,** 26–32, 1955].

Yu. P. Grigor'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1168. Ifrim, M., Appreciation on the fundamental vibration frequency of tall structures subjected to seismic actions (in English), *Rev. Mecan. Appl. Acad. Repub. Pop. Romine,* **4,** 1, 159–172, 1959.

Author establishes the upper and lower limits of the natural frequencies of vibration. He proves that the lower limit coincides with the approximate value which might be obtained through the application of Geiger's formula. The upper limit is obtained by considering that the first mode of vibration varies linearly with the height or is proportional to the static deformation of the system. A more exact value is obtained through the introduction of a correction coefficient ψ, function of the static and geometric elements of the structures. The proposed relations are applicable to any type of multistory buildings.

Applications of the theory are also included.

M. Soare, Roumania

1169. Paslay, P. R., and Slibar, A., Lateral vibration of guided trailers (in German), *Ing.-Arch.* **26,** 6, 383–386, Dec. 1958.

Equations of motion for small lateral vibrations of guided trailers on a horizontal plane are developed for constant towing velocities. Terms due to the lateral thrust on wheels with pneumatic tires are included. The system is reduced to one with only two degrees of freedom, for which the secular equation is obtained.

Expressions for the characteristic frequencies were derived by neglecting the damping terms in the equations of motion.

E. G. Newman, USA

1170. Grigor'ev, E. A., Dynamic stability of a ring under the action of normal periodic impulses (in Russian), *Nauchno-tekh. Inform. Byul. Leningrad Politekhn. In-ta* no. 12, 68–74, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11469.

An investigation is carried out on the stability of a ring under the action of periodic impact impulses. The basic differential equation for the motion and the equation for the vibrations are put forward. The boundaries of the regions of instability are determined by the methods of operational calculation. It is established that there exist periodic solutions with periods of $2T$ and $4T$ at arbitrarily assigned initial values, where T represents identical intervals of time in which impulses of identical magnitude and opposite direction are applied. It should be noted that there exist auxiliary periodic solutions with a period of $4T$, for which specially selected initially assigned values are required.

Yu. S. Shkenev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1171. Ungar, E. E., and Ross, D., Damping of flexural vibrations by alternate visco-elastic and elastic layers, Proc. Fourth Midwest. Conf. Solid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 1959, 468–487.

Paper outlines theoretical treatment of title problem for single and multiple tapes. Solutions to general equations are presented for case of multiple tapes having identical properties. Results presented show that damping effectiveness is largely independent of number of tapes if total weight of metal and adhesive is constant. One set of experimental-theoretical comparisons shows reasonably good agreement.

K. H. Griffin, England

1172. Khil'chevskii, V. V., Determination of the parameters of the hysteresis loop characterizing the damping properties of a material (in Russian), *Izv. Kievsk. Politekhn. In-ta* **20,** 272–277, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11846.

The damping properties of metals depend on the size of the stresses which are produced in them in consequence of vibrations. These properties are taken into account by means of two parameters, one of which determines the form while the other establishes the size of the area of the hysteresis loop. An attempt is made to select these parameters in such a way that the area of the hysteresis loop remains the same for different stresses.

A. D. Pospelov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Wave Motion and Impact in Solids

(See also Revs. 1088, 1110, 1171)

1173. Allen, W. A., Morrison, H. L., Ray, D. B., and Rogers, J. W., Fluid mechanics of copper, *Physics of Fluids* **2,** 3, 329–333, May–June 1959.

For extremely high pressures and accelerations a metal such as copper can be considered as an inviscid compressible fluid; it can be characterized by an experimentally determined Hugóniot curve. The impact of a projectile on a target then becomes a problem in supersonic (or subsonic) flow theory. Paper gives graphs for shock relations in copper and applies them to a practical problem.

K. G. Guderley, USA

1174. Gusein-Zade, M. I., On the acoustic theory of spalling, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **22,** 4, 763–767, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Paper deals with the scabbing problem. Solution for an arbitrary force is represented in terms of that due to an impulse as a convolution integral. The wave equation for the displacement potential is solved in cylindrical coordinates by the application of the Laplace and the Hankel transforms. The stresses due to the incident and the reflected waves along the axis are obtained by the use of contour integration. It is shown that face-spalling cannot occur and, for rear-spalling, an expression for the depth where the destructive stress is first attained is obtained. The solution, as noted, differs from the one obtained by considering the point-force as a limiting case, a point on which there has been much discussion recently.

G. A. Nariboli, India

1175. Chakravorty, S., Disturbances due to localized periodic surface traction in a semi-infinite elastic medium with transverse isotropy (in English), *Riv. Mat., Parma* **8,** 4/5, 375–379, 1957.

Steady-state periodic solution in a semi-infinite elastic medium possessing transverse isotropy about a line perpendicular to the boundary plane surface is obtained by classical methods. The source of the disturbance is assumed to be a concentrated normal force on the plane surface, sinusoidal in time.

L. E. Malvern, England

1176. Skuridin, G. A., On the theory of dissipation of elastic waves on a curvilinear boundary (in Russian), *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 2, 160–183, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11456.

The approximate solution of the first boundary problem in the theory of elasticity (displacements are assigned on the boundary) is demonstrated; this covers the case of an assigned elementary falling wave with varying forms of cylindrical surfaces, and with a steady state in relation to time. The solution is derived individually for a longitudinal and a transverse wave on the assumption that the reflection at an arbitrary point of the boundary surface shall be such as would be reflected with its small surroundings a plane (surface). Graphs are given illustrating the qualitative picture of the phenomenon; the fact is ignored that a full theoretical solution of boundary problems, of which the case cited is a particular instance, is known, though the author refers to a sufficiently wide range of literature on the subject.

V. D. Kupradze

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1177. Bogoroditskii, A. M., Application of the theory of thin rods to the solution of some problems of dynamic compression of coiled springs (in Russian), *Trudi Tul'sk. Mekhan. In-ta* no. 8, 185–194, 1958; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11481.

Solutions are given for the following problems: (1) Compression of the spring by dynamic force; the spring is preliminarily compressed, the upper supporting coil is full, the lower is clamped on an immovable stiff support. (2) Compression of the spring by impact, delivered by an absolutely rigid body of a given mass; one end of the spring is clamped and the impact body during delivery of the blow does not lose contact with the supporting coil of the spring. The spring is looked upon as a combination of plane coils and its vibration is described by a system of differential equations derived by Love. An approximate solution for the system is obtained by the system of resolution on the small parameter and by the Laplace-Carson integral conversion. For the small parameter the magnitude a^3Q/EJ is selected where EJ is the deflection stiffness of the wire, Q the weight of the wire, a the radius of the elastic axis of the spring. It is noteworthy that the method used by the author gives more accurate results than the wave theory of dynamic compression in those cases where the mass of the attached body is greater than the mass of the spring.

M. V. Khoingiya

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1178. Bagreev, V. V., Research into the bending impact of a weight on a beam (in Russian), Avtoref. Diss. Kand. Tekhn. Nauk, Mosk. In-ta Inzh. Zh-d. Transp., Moscow, 1958; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7968.

1179. Shakhsuvaryan, L. V., Analysis of the working of butt joints in decking beams under seismic shock (in Russian), *Izv. Akad. Nauk ArmSSR, Ser. Tekhn. Nauk* **10**, 5, 45–54, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 8162.

1180. Gorkov, P. I., Problem of an impact of a cargo on a bearer beam (in Russian), *Trudî Mosk. In-ta Inzh. Zh.-d. Transp.* no. 92/11, 137–152, 1957; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 992.

Soil Mechanics: Fundamental

1181. Seed, H. B., and Reese, L. C., The action of soft clay along friction piles, *Trans. Amer. Soc. Civ. Engrs.* **122**, 731–764, 1957.

Paper presents the results of load distribution tests on instrumented pipe piles driven into relatively uniform organic silty clay. By means of a series of tests, the increase in load capacity was measured, and the distribution of load from pile to soil was determined for each test. Soil samples were taken adjacent to similar unloaded piles at various intervals subsequent to driving to determine shear strength changes. The pile loading rate was necessarily much faster than conventional rates.

The load capacity increased more than five times during the period of 30 days following driving. This increase is attributed to an increase in the soil shear strength of 60 per cent over the original undisturbed strength. An initial loss of shear strength by remolding during driving was measured.

Load distribution data indicate the major part of the pile load is transferred to the soil at the greater depths, the soil near the surface being relatively ineffective in this respect. This pattern was consistent for all test stages. The pile was supported almost entirely by perimeter forces, the tip accounting for only 10 per cent of the total load. It should be noted that these results were obtained for small (6-in. diameter) piles of shallow embediment (15 feet) in a soft saturated clay. The ultimate load capacity did not exceed 6000 pounds. P. P. Brown, USA

1182. Volarovich, M. P., Gusev, K. F., Markov, S. N., and Tropin, V. P., Change in structure, degree of dispersion and limits of shear stress of peat when frozen through (in Russian), *Kolloid. Zh.* **19**, 4, 401–405, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 7013.

The limits of shear stress of peat were determined by means of a conical plastometer. Authors explain the lowering of the limit of shear stress of the frozen-through and thawed-out peat by the coagulation of the turf when frozen through and the increase of the free water content caused thereby. When the turf is exposed to prolonged periods of positive temperatures it re-establishes in part its initial rheological properties. N. I. Malinin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1183. Nash, K. L., Repeated stresses in soil as the basis for pavement design, Proc. Midland Soil Mech. Found. Engng. Soc. **2**, Pap. no. 9, 19–32, Mar. 1958.

1184. Murayama, S., and Sibata, T., On the dynamic consolidation of clay (in Japanese), *Trans. Japan Soc. Civ. Engrs.* no. 62, 42–48, May 1959.

This is a report of theoretical and experimental research on the dynamic consolidation of clay. Assuming that the clay constitution has the rheological model proposed in an earlier paper [AMR 11 (1958), Rev. 1412] a fundamental formula concerning the dynamic consolidation is derived, and the experimental results are analyzed in order to give some quantitative characteristics of dynamic consolidation of clay. From authors' summary

Courtesy, Editorial Committee of the Japan Society of Civil Engineers

1185. Ephremidis, C., Establishing mathematically the soil compaction procedure (in German), *ZVDI* **101**, 7, 277–280, Mar. 1959.

Knowledge acquired through practical test results is of great importance for the selection of vibratory compactors. But theoretical data are more important which, from the outset and without practical tests, enable the most suitable vibrators to be developed for the respective working conditions. The mass of the pan, the unbalanced weight, exciting frequency and spring must be in a certain relation to each other and to the soil characteristics on a suitable vibrator; from this, terms can then be expressed for the percussive force, impact energy and compaction effect. A tester based on theoretical knowledge enables the performance and effect of a vibrator to be measured directly.

From author's summary

1186. Sokolov, V. A., Calculations for the dynamic loading of a movable nature when determining the stability of slopes of an earth roadway (in Russian), *Trudî Novosibir. In-ta Inzh. Zh.-d. Transp.* no. 12, 30–39, 1955; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5860.

Laboratory apparatus is described for determining the soil resistance to shear during vibrations at different frequencies and amplitudes. The amplitude was recorded by means of a seismograph type ABEM and an oscillograph MPO-2. With the aid of such apparatus data were obtained for a dusty argillaceous soil, characterizing the change of the coefficient of internal friction and cohesion in relation to the size of the vibration amplitude at a given frequency. These vibrations were selected in such a way as to simulate the vibrations of the soil in the vicinity of a railway track over which a train was passing. The coefficient of internal friction decreased by three times and of cohesion by twice with an amplitude of vibration of 60μ, in comparison with the case where the vibration was nil. Author examined the influence of troughs to protect embankments of railway cuttings from vibrations caused by passing trains. G. I. Pokrovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1187. Gol'dshtein, M. N., and Ter-Stepanyan, G. I., Prolonged stability of clays and the deep-seated creep of slopes (in Russian), 4th International Congress on the Mechanics of Soils and Foundation Construction, Moscow, Akad. Nauk SSSR, 43–51, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5870.

In the first part (M. N. Gol'dshtein) the influence is investigated of unloading and resting on a clay of compact-plastic and semi-solid consistency. A rheological model is supplied, and a simple empirical formula of logarithmic form to show the duration of the stability. Preliminary tests, requiring more extensive confirmatory investigations, established the fact that the relative deformation up to the moment of disruption is independent of the duration of the action produced by the load. A method is proposed for the determination of the duration of stability on a single sample. In the second part (G. I. Ter-Stepanyan) an examination is made of one of the preparatory phases of creep, called deep-seated flow (deep-seated creep), in slopes. An integral formula is given for the determination of the velocity of the deep-seated creep, and an investigation is also made of the distinction between zones of deep-seated creep and the surfaces of slip.

G. S. Grigoryan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1188. Kezdi, A., Factors influencing the stability of slopes (in Czechoslovakian), *Stavebnicky Casopis* **6**, 1, 18–27, 1958.

Book—1189. Lomize, G. M., and Netushill, A. V., Electro-osmotic lowering of ground water level [Elektroosmotitcheskoe vodoponijenie], Moscow and Leningrad, Gosenergoizdat, 1958, 176 pp. 5.60 Rubles.

Book analyzes the development of electro-osmotic process in soils, taking into account the characteristic structure of clay mycellium and pointing out the peculiarities of electro-osmotic current in coarse-grained soils (medium and coarse sands), in very clayey soils (silty clays and clays) and in intermediate types (loose silty clays and fine sands). Stress is laid on the multilateral examination of the electro-osmotic coefficients. Proceeding from considerations of dimensional analysis, authors establish correlations between the electro-osmotic permeability coefficients and other soil characteristics and present experimental verifications of the obtained equations. The effect of the simultaneous action of the electric and hydrodynamic fields is discussed, reaching the conclusion that, in certain soils, the electro-osmosis increases the hydrodynamic permeability. An examination of the way in which the electro-osmosis develops when the anode is not supplied with water shows that in the anode zone negative tensions develop in the ground water reaching up to a critical value of 0.3–0.8 atm, after which the water menisci begin to separate from the anode. In the calculation of the electro-osmotic current velocity, besides the coefficients corresponding to the electric and hydrodynamic gradients, the influence of the moisture gradient is also introduced.

An important part of the book is devoted to model testing and calculation of the electro-osmotic lowering of the ground water level. The main way of approaching this problem is by using the electro-hydrodynamic analogy method. The case is dealt with when the action of the electric field and that of the hydrodynamic one are added up directly, the soil characteristic coefficients are constant, the anode is not supplied with water, and the soil compressibility due to electro-osmosis may be neglected. The boundary conditions necessary for solving the system of equations that results from applying the foregoing considerations are presented for cases currently met with in practice.

As certain difficulties are encountered with the spatial problem, solutions are given for reducing it to a plane one. For the case in which the electrodes are distributed on a rectangular boundary, an approximate but rapid and convenient method of analytic calculus is given.

One chapter is devoted to practical applications of the electro-osmotic lowering of ground water level. Stress is laid on the case when the lowering is performed with the aid of electro-osmosis and suction (cathodes acting as well points). The positive effect of this method on the stability of fine soils, unstable under hydrodynamic action and hardly giving up water, is explained by the water-tensioning as a sequence of the vacuum and electro-osmosis operations. Authors consider that the electro-osmotic ground water lowering is effective in soils whose electro-osmotic permeability coefficient is at least ten times greater than the hydrodynamic one.

Reviewer believes that the original material presented in this book opens new perspectives for the study of electro-osmosis and proves that this problem, although much discussed, is far from being exhausted. R. J. Bally, Roumania

Soil Mechanics: Applied

(See Rev. 1236)

Processing of Metals and Other Materials

(See also Rev. 1209)

1190. Pelphrey, H., Chipless forming of toothed parts by rolling, ASME Production Engng. Conf., Detroit, Mich., May 1959. Pap. 59-PROD-12, 8 pp.

Chipless forming of toothed parts by rolling improves quality and at reduced cost. Simply expressed, material is pressed down to form the minor diameter which causes material to flow upward to form the upper portion of the teeth. The rolling stroke of the process takes from 3 to 5 sec. Combinations of splines and threads and the like can be accomplished in sequence with one machine stroke. Most of the work has been done at room temperature. However, when the spaces between the teeth are deep and there is a lot of generation, it becomes necessary to heat the parts. Gears, in most cases, are in the latter class.

From author's summary

1191. Colding, N., Shear spinning, ASME Production Engng. Conf., Detroit, Mich., May 1959. Pap. 59-PROD-2, 12 pp.

In this paper a relatively new method for shaping of metals by plastic deformation is described. The method dealt with here was developed by the author's company under the trade mark "Hydrospin." This process, which uses a roller to deform metal plates plastically into conical, or other shapes of circular cross section, such as hemispheres, may be technically described as shear spinning because of the sine-law condition. Technical data on the machine and the tooling are given. Analytical expressions for shear-spinning stresses and tangential force are suggested on the basis of the combined rolling and extrusion of the metal. On the basis of these elementary considerations, values for the maximum theoretical reduction are derived for an ideally plastic material and for a typical strain-hardening material. The efficiency of deformation is investigated on the basis of experimental values of the tangential force. From author's summary

1192. Lueg, W., and Funkejun, P., The yield point behavior of rerolled aged sheets made of deep-drawn steel (in German), *Stahl u. Eisen* **79**, 14, 969–976, July 1959.

Authors consider skin-pass rolling of strip made of deep-drawn steel, particularly its susceptibility to ageing. Possibilities are considered of interpreting the yield point behavior and ageing by applying the dislocation theory. Authors also discuss relation between the yield point behavior and the tendency to the formation of stretcher lines; influence upon the yield point behavior by providing different conditions in the skin pass; influence of the number of passes and of the diameter of the rolls; yield point elongation as dependent on the time of ageing; and recommended practices for skin-pass rolling with a view to the behavior in ageing.

From authors' summary

1193. Parks, J. R., and Hill, M. J., Design of extrusion augers and the characteristic equation of ceramic extrusion machines, *J. Amer. Ceram. Soc.* **42**, 1, 1–6, Jan. 1959.

1194. Talantov, N. V., On the problem of the analytical method in determination of the cutting temperature, *Soviet Phys.-Tech. Phys.* **4**, 1, 123–126, July 1959. (Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **29**, 1, 141–145, Jan. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

Paper deals with analytical evaluation of the average tool-chip interface temperature. It differs from the existing solutions in that it considers the finite thickness of the plastically deformed layer adjacent to the rubbing surface of the chip. Temperature rise at

the interface due to such volume heat source is obtained by integrating the well-known point source solution.

A few results of the computed average temperature at several cutting speeds are presented graphically and compared both with experimental data and those calculated from the plane heat source theory. Author's derivation assumes that the strength of the volume source is uniform throughout the deformed layer, the thickness of which is determined from photomicroscopic study.

B. T. Chao, USA

1195. McKee, R. E., Effects of machining forces on tools, *Tool Engr.* **43,** 1, 65–72, July 1959.

The author describes the results of force analysis tests and shows how they are applied to the design of lathes.

From author's summary

1196. Kececioglu, D., Shear-zone size, compressive stress, and shear strain in metal cutting and their effects on mean shear-flow stress, ASME Production Engng. Conf., Detroit, Mich., May 1959. Pap. 59-PROD-3, 9 pp.

A relationship for the calculation of the shear-zone size is given. The shear-zone size, when machining SAE 1015, 118 Bhn seamless steel tubing under a wide range of cutting conditions, is found to vary from 0.95×10^{-6} in.^{3} to 61.5×10^{-6} in.^{3}. The mean shear-flow stress is found to increase significantly with a decrease in the shear-zone size and with an increase in the compressive stress in the shear zone. It is concluded that the only size-effect in metal cutting is the shear-zone size-effect, and that no separate depth-of-cut size-effect should be sought. An apparent decrease in the shear-flow stress with an increase in the true, mean shear strain in the shear zone is observed.

From author's summary

1197. Lamm, M. M., Chip formation in metal cutting—a hydrodynamic theory, *Engineering* **187,** 4856, 444–446, Apr. 1959.

1198. Galimberti, J. M., Hahn, R. S., Siekmann, H. J., and Thomsen, E. G., 1958 review of metal processing literature (metal cutting analysis), ASME Prod. Engng. Conf., Detroit, Mich., May 1959. Pap. 59-PROD-6, 5 pp.

1199. Ball, A. L., Controlling grinding stresses, *Tool Engr.* **42,** 4, 121–125, Apr. 1959.

Residual grinding stresses in a work-piece can be controlled within limits, both with respect to type and extent. Examples demonstrate effects of wheel type, downfeed and coolant on stresses in hardened steel. Bath and quench also effectively reduce stresses. Critical effects of downfeed in grinding titanium are also discussed. From author's summary

1200. Barnitz, R. W., and Terwilliger, G. E., Application of data-logging and programming techniques to steelmill processes, ASME-AIEE-IRE Conf. Automatic Techniques, Chicago, Ill., May 1959. Pap. 59-AUT-5, 8 pp.

The areas of automation in a steel plant may consist of (a) scheduling, (b) mill or process setup for programming, (c) process control, (d) data logging. Each of these areas is described and present applications are used to demonstrate future possibilities.

From authors' summary

Fracture (Including Fatigue)

(See also Revs. 1124, 1174, 1214, 1436, 1573, 1574)

1201. Lauchner, J. H., and Bennett, D. G., Thermal fracture resistance of ceramic coatings applied to metal, Part I, Elastic deformation, *J. Amer. Ceram. Soc.* **42,** 3, 146–150, Mar. 1959.

A study was made of the resistance to thermal fracture of four ceramic coatings of the cobalt-bearing ground-coat type applied to enameling-grade iron specimens. The study was made of coated-metal systems in the unsteady state, symmetrically cooled, and in the absence of viscous or plastic flow. Determinations were made of the elastic characteristics of the coating-metal composites, the effective coefficient of linear expansion, the temperature at which the coating and base metal were at dimensional equilibrium, and the temperature differential sufficient to induce coating fracture when water quenched. Coating-metal thickness ratios were correlated with the maximum specimen temperature withstood in water quenching without coating fracture. Studies indicated that ceramic coatings, after receiving a given thermal treatment, fracture when subjected to a thermal shock by a critical temperature differential. When no residual coating stress is present, thermal shock resistance is inversely related to the thermal expansion characteristics of the coating. The critical stress at which coating fracture occurs may be expressed as the sum of thermal and residual stresses developed in annealed systems in which viscous or plastic flow does not occur. Residual compressive stress in a coating is a major factor in improved thermal shock resistance. Increased thermal shock resistance is gained by decreased coating thickness. From authors' summary

1202. Schaller, F. W., and Zackay, V. F., Low temperature embrittlement of austenitic Cr-Mn-N-Fe alloys, *Trans. Amer. Soc. Metals* **51,** 609–628, 1959.

The ductility of austenitic Cr-Mn-N-Fe alloys has been studied as a function of test temperature, interstitial content, and strain rate. The low temperature brittleness encountered was explained using a model with strain-induced martensite as the embrittling agent. At high strain rates, an anomalous increase in reduction of area was found and attributed to a localized temperature increase of the specimen. From authors' summary

1203. Romualdi, J. P., and Sanders, P. H., Fracture arrest by riveted stiffeners, Proc. Fourth Midwest. Conf. Solid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 1959, 74–90.

The total stress intensity factor at the tip of a crack is theoretically determined, and good agreement is obtained between calculated values and those determined by strain gages. The kinetic energy of the material surrounding a running crack is found to be an important factor affecting the maximum rivet force at fracture arrest. Tests show that when a running crack is stopped by a riveted stiffener the maximum rivet force can be as much as 25% greater than that which would be obtained with a slowly moving crack. D. Kececioglu, USA

1204. Johansen, K. W., Fracture of stones and concrete (in Danish), *Bygnsstat. Medd.* **29,** 2, 25–44, Nov. 1958.

1205. Bresler, B., and Pister, K. S., Failure of plain concrete under combined stresses, *Trans. Amer. Soc. Civ. Engrs.* **122,** 20 pp., 1957.

To obtain further evidence on failure of plain concrete, hollow cylinders were tested under varying combinations of torsion and compression. Data obtained from these tests indicate a direct correlation between normal and shearing octahedral stresses at failure. Within the limits of available data, the octahedral-stress criterion was generalized to include the effect of the third stress invariant, and in this form the proposed criterion was shown to be in satisfactory agreement with the previously reported data.

From authors' summary by P. M. Ferguson, USA

1206. Oding, I. A., and Geminov, V. N., A new law of creep rupture, *Soviet Phys.-Doklady* **3,** 5, 1002–1005, May 1959. (Translation of *Doklady Akad. Nauk SSSR (N. S.)* **122,** 2, 222–225, Sept. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

It is considered that rupture will occur after vacancies generated by moving dislocations coalesce into microcracks. On this basis, four equations are suggested for successive portions of the stress-log time curve. Analysis of 130 creep-rupture curves for various grades of steel indicated that the first two of the four equations would cover lines up to 100,000 hours and that the data could be represented by two straight-line segments, the slope of the second being one-fourth that of the first. For alloys of other base metals the relations between the slopes of the line segments will be different. M. Holt, USA

1207. Cummings, H. N., Stulen, F. B., and Schulte, W. C., Fatigue strength reduction factors for inclusions in high strength steels, WADC TR 57-589 (PB 131 816; ASTIA AD 151 162), 32 pp., Apr. 1958.

Tentative values of fatigue strength reduction factors for nonmalleable inclusions in single-nucleus fractures of R. R. Moore rotating beam specimens are determined by two methods. Data for the computations are taken from tests on 309 specimens of SAE 4340 and 4350 steel, of 140, 190, 230, 260 and 300 ksi UTS. Quantitative results are thought to be somewhere near the correct order of magnitude. Qualitatively it is concluded that the values of the factors depend upon the size of the inclusions and upon the hardness level of the steel. Also, it is thought that for very small inclusions (less than 0.00025 inch) other inhomogeneities inherent in the steel itself dominate the failure of a specimen.

From authors' summary

1208. Majors, H., Jr., Thermal and mechanical fatigue of nickel and titanium, *Trans. Amer. Soc. Metals* **51,** 421–437, 1959.

Thermal and load-cycling tests were conducted on 0.500-in. diam thin-walled tubes of titanium and nickel in direct loading under a constant mean temperature. The stresses and plastic strains were obtained. Controlled loading conditions were maintained by means of automatic electric timing circuits and resistance heating of the specimens. Analysis of the microstructure shows the influence of thermal cycles.

From author's summary

1209. Wall, P. H., Stress corrosion—the engineer's view, *J. Roy. Aero. Soc.* **63,** 582, 354–365, June 1959.

Many practical examples of stress corrosion cracking are shown, as well as the design or manufacturing deficiencies which contribute to the cracking. Design considerations are reviewed in detail, particularly those causing serious, and often overlooked, assembly stresses. Manufacturing considerations include care in assembly, forming to avoid residual stress, heat treating to avoid residual stress, and protective treatments. Use of torque-wrench tightening of bolts, stretch forming, shot peening, and control of heat treating variables are emphasized.

J. D. Lubahn, USA

1210. Upp, J. R., Beck, F. H., and Fontana, M. G., Influence of nickel on intergranular corrosion of 18% chromium steels, *Trans. Amer. Soc. Metals* **50,** 759–772, 1958.

Experimental Stress Analysis

(See Rev. 1203)

Material Test Techniques

(See Revs. 1205, 1569)

Properties of Engineering Materials

(See also Revs. 1095, 1097, 1098, 1101, 1104, 1119, 1172, 1204, 1205, 1206, 1207, 1208, 1209, 1225, 1505, 1572)

1211. Fieldhouse, I. B., Hedge, J. C., Lang, J. I., and Waterman, T. E., Thermal properties of high temperature materials, WADC TR 57-487 (PB 131 718; ASTIA AD 150 954), 79 pp., Feb. 1958.

The objective of this program was the measurement of the high temperature thermal properties of materials. The materials investigated were Hastelloy B, Hastelloy C, Stellite 21, Stainless Steel type 17-7 P. H., Stainless Steel type 446, Silicon Carbide, 60–15 Cr (ASTM B83-46), and beryllium. The thermal conductivity, specific heat, and linear coefficient of thermal expansion were measured from 1000F to 3000F, or the melting point of the material, whichever was lower. Both the experimental measurements and the results of the conversion of these measurements to the desired physical properties are given.

From authors' summary

1212. Berger, L. W., Williams, D. N., and Jaffee, R. I., Mechanical properties and heat treatment of titanium-niobium alloys, *Trans. Amer. Soc. Metals* **50,** 384–397, 1958.

1213. Matsunaga, S., On the theory of bi-metal (in English), *ZAMM* **38,** 9/10, p. 402, Sept./Oct. 1958.

1214. Hiorns, F. J., Mechanical properties of non-metallic brittle materials, *Brit. Coal Utilisat. Res. Assn. Bull.* **22,** 10, 395–408, Oct. 1958.

In April 1958 the Mining Research Establishment of the National Coal Board sponsored a two-day conference dealing with the mechanical properties of coal, carbon and graphite, rocks, bricks, concrete and plaster. Paper presents a review of the 27 contributions grouped in 4 sessions: (1) Strength in compression, tension, bending and shear; (2) Elasticity and creep; (3) Dynamic loading, impact and fragmentation; and (4) Action of tools. Review is mainly qualitative, encompassing a multitude of tests, test conditions and materials without fully characterizing the materials to be tested. F. Forscher, USA

1215. Okushima, M., and Kosaka, Y., Fundamental study on the non-elastic properties of concrete, *Technol. Rep., Osaka Univ.* **8,** Pap. 318, 8 pp., Oct. 1958.

Authors measure logarithmic decrement and resonance frequency of concrete rods and, by assuming a Maxwell body, calculate their elastic and viscous constants. These they compare with constants obtained in static tests. The resulting incompatibility suggests that concrete is better described by means of a Burgers model. A Voigt model would require direct proportionality between logarithmic decrement and frequency, whereas actually inverse proportionality was observed.

J. Glucklich, Israel

1216. Zagar, L., Ceramics and glass and their application in modern aeronautics, AGARD Rep. 179, 15 pp., Apr. 1958.

1217. Boller, K. H., and Kimball, K. E., Strength properties of reinforced plastic laminates at elevated temperatures; DC 2106 resin and 181 heat-cleaned glass fabric, WADC TR 59-229, 54 pp., Mar. 1959.

Several reinforced plastic laminates that show promise of having good strength properties at elevated temperatures are being tested to determine their strength and elastic properties. This report describes the methods used in testing such laminates after exposure periods of up to 1000 hours. Flexural, tensile, compressive, interlaminar shear, and bearing tests parallel to the warp direction are made to determine the effects of high temperature and time exposed at a given temperature on the strength properties. Tensile tests at 45° to the warp direction are made to obtain data from which edgewise shear strength and modulus of rigidity can be calculated. Creep and stress-rupture data are obtained under both tension and compression loads. In addition to strength properties, data are obtained on the deterioration of the laminated material at elevated temperatures.

This is the first of several reports that are planned as a part of this work. Data for laminated material made of DC 2106 resin and 181 heat-cleaned glass fabric are presented in both tables and charts. In general, it is shown that strength properties decreased with an increase in temperature. At temperatures up to and including 600F, strength properties were usually not appreciably affected regardless of the time they were held at the high temperature. From authors' summary

1218. Boller, K. H., and Kimball, K. E., Effect of elevated temperatures on weight loss and flexural properties of three reinforced plastic laminates. WADC TR 59-216, 27 pp., Feb. 1959.

This report presents data showing the effects of elevated temperatures for various exposure periods on the deterioration (weight loss) and flexural strength properties of three reinforced plastic laminates; a silicone-glass laminate (DC 2106 resin and 181 heat-cleaned glass fabric), a phenolic-glass laminate (CTL-91LD resin and 181-A1100 glass fabric), and a phenolic-asbestos laminate (R/M Pyrotex felt Style 41-RPD).

The test methods are described and data are presented in tables and curves. From authors' summary

1219. Adams, C. H., Plastics: Engineering materials, *Trans. Amer. Soc. Civ. Engrs.* **123,** 15 pp., 1958.

This paper is concerned solely with the engineering characteristics of plastics. A description of the reaction of these materials to the various environmental factors of force, time, temperature, and humidity is presented. The magnitude of the subject requires a generalized treatment, such as that which would be used in a description of the engineering characteristics of metals. The subject is developed through a series of comparisons of plastics by generic groups; a selected set of quantitative comparisons with other materials; and, finally, an analysis of certain pertinent design considerations.

From author's summary by A. Erdely, Argentina

Structures: Simple

(See also Revs. 1112, 1118, 1125, 1129, 1130, 1152, 1161, 1209, 1218)

1220. Kappus, R., and Clerc, D., Response matrix of an elastically suspended structure (in French), *Rech. Aéro.* no. 64, 49-56, May-June 1958.

The response matrix of a structure suspended in any manner is determined either by using static tests or through the summation of the various individual contributions. As typical examples, the cases are discussed of a symmetric body symmetrically suspended by two elastic suspensions, of a body symmetrically suspended by four elastic suspensions, as well as the case of a schematically presented aircraft. A. L. Petre, Roumania

1221. Sbarounis, J. A., and Gaus, M. P., Analysis of a two way truss system, *Proc. Amer. Soc. Civ. Engrs.* **85,** ST 2 (*J. Struct. Div.*), 45-69, Feb. 1959.

The analysis of a two-way truss system forming a space grid is described. This grid can be rigidly or elastically supported as desired. Two methods of analysis are presented, of which the first is based on the method of consistent deflections and the second on the solution of an anisotropic flexural grid. Application of the methods in the analysis and design of the U. S. Air Force Academy Dining Hall at Colorado Springs, Colorado is discussed. From authors' summary

1222. Taneda, M., Experiments on box-type girders, *Bull. JSME* **2,** 5, 131-137, Feb. 1959.

In order to study the strength, the rigidity, etc., of box-type girders for overhead travelling cranes, full-sized model experiments were conducted. Two model girders were used. The upper deck and the two web plates of one model (Girder 2) were reinforced by longitudinal stiffeners, while those of the other (Girder 1) were not. Load was applied on top of the inner web plate at the center of the span of each girder, which was supported at its ends.

Results are as follows:

(1) The stress distributions on the plate surfaces were generally irregular, while deflections, buckling loads, failure loads of girders and shapes of plates after failures were coincident with their calculated values.

(2) The effects of longitudinal stiffeners on the strength of Girder 2 appeared clearly.

(3) The torsion produced by the eccentric load has not a remarkably bad effect on a box-type girder of such dimension ratio as used in the present experiments.

From author's summary

1223. Bianchi, G., General method for the calculation of continuous beams (in Italian), *G. Gen. Civ.* **96,** 11, 726-730, Nov. 1958.

A known system of three moment equations for a continuous beam is solved. This leads to recurrence relations for support moments. Presentation is clear.

S. J. Medwadowski, USA

1224. Zamakhaev, V. M., The problem of the influence of the initial distortions on the work of welded bridge constructions (in Russian), *Trudl Mosk. Avtomob.-dor. In-ta* no. 21, 133-141, 1957; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11753.

Information is furnished regarding the considerable faults, discovered experimentally, in the ribs and in the vertical thin walls of high beam bridges of continuous section. An attempt is made to evaluate approximately the change in the stressed condition near the buckling by means of the mean stresses without taking into account the deflection. I. K. Snitko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1225. Gatewood, B. E., and Jones, C. R., Optimum design of stiffened panels and sandwich panels at elevated temperature, Proc. Fourth Midwest. Conf. Solid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 1959, 270-297.

For optimum design of a structure under tension loads, only knowledge of material properties is required, such as ultimate tension and tension yield stress plotted against temperature, creep rupture, creep to a given deformation and permanent set due to creep plotted against a temperature-time parameter. For optimum design of compression elements the several allowable compressive stresses are taken into account such as column buckling stress, plate or local buckling stress, or crippling stress. The method allows optimizing the individual elements of the (aircraft)

structure consistent with space and joint limitations as well as the optimization of the overall structural arrangement. Useful design diagrams are given for formed and extruded sections, stiffened panels and sandwich panels. Six heat-resistant alloys are considered. J. P. Benthem, Holland

1226. Skaberne, L. J., and Treppo, L., Reinforced concrete floors and roofs with clay hollow blocks system SAT (in Slovenian), *Gradbeni Vestnik, Ljubljana* **10,** 61/64, 22–26, 1958/59.

Paper describes prefabricated straight and curved (for roofs) units, their design and erection. Results of tests under concentrated load (with units about 15 ft long) are recorded and presented in diagrams. Application is made to a factory building with circular roof spanning 44 ft and two flat roofs on each side having 20-ft spans. J. J. Polivka, USA

1227. Turk, S., Simplified design of reinforced concrete members under eccentric loads (in Slovenian), *Gradbeni Vestnik, Ljubljana* **10,** 61/64, 33–40, 1958/59.

Another article on author's simplified method of designing concrete members with double reinforcement subject to eccentric loads and combined loading pressure and bending moments and under consideration of buckling, which is treated in a new way. Nonrectangular and other types of irregular sections are also considered. J. J. Polivka, USA

1228. Bennett, E. W., Graphical method for the design of prestressed beams, *Concr. Const. Engng.* **53,** 11, 399–403, Nov. 1958.

In the title source for May 1952 author gave partly graphical method to determine section properties of prestressed concrete beam with predetermined loadings and permissible stresses. Present paper presents graphical method for determining prestress, knowing section properties. Author first shows graphical construction of prestress diagram for a known prestressing force P acting at eccentricity e_x. Although method is simple, it is probably quicker to calculate directly from expressions of type $P/A\ (1 \pm e_x\, y/r^2)$. A first example demonstrates, for a given prestressing diagram and predetermined eccentricities, the proportioning of the resultant prestressing force P into two forces representing groups of prestressing tendons at two levels e_1 and e_2 in the beam. This also is simple construction and probably quicker than direct calculation of $\alpha = [Z_b/P(f_b - P/A) + e_2]\ 1/(e_1 + e_2)$ where α is proportion of P at level e_1, Z_b and A are modulus and area of section, and f_b is maximum prestress. Author then demonstrates determination of limits of prestress diagram to satisfy allowable compressive and tensile forces in concrete in conjunction with maximum and minimum applied moments. This has the merit of clarifying requirements of the four maximum and minimum stress equations and of reducing possible errors in their solution. Two further examples combine the graphical solutions discussed to determine the required prestressing forces.

In common with many graphical solutions, value increases with complexity of problem. Some disadvantage arises in that total prestress can be proportioned at only two levels. Repetition would be required for increased number of eccentricities using stress resultants of pairs. Nevertheless paper should be of especial interest to engineers who are not prestressed concrete designers. G. Little, England

1229. Bergstrom, R. N., Overload factors can cause ultra-conservative design, *Proc. Amer. Soc. Civ. Engrs.* **85,** ST 2 (*J. Struct. Div.*), 71–79, Feb. 1959.

Paper reviews the use of overload factors in establishing design stresses for reinforced-concrete and prestressed-concrete structures and for steel transmission towers. It compares this with results of conventional design stress assumptions and finds overload factors create a much higher safety factor than would normally be expected. From author's summary

Structures: Composite

(See also Revs. 1171, 1511, 1512)

1230. Andra, W., and Leonhardt, F., Simplified method for the measurement of fields of influence in plates (in German), *Bauingenieur* **33,** 11, 407–414, Nov. 1958.

This paper deals with a procedure which permits the direct drawing up of fields of influence by means of level lines, through the measurement of curvatures with a mechanical device that allows the simultaneous determination of the curvature in two perpendicular directions. Authors give a detailed account of the theory and technique of the method and also the comparison of the results of the measurement with those of the rigorous calculation. The procedure is specially interesting for plates of arbitrary shape and boundary conditions found in many modern bridges and buildings. J. L. Delpini, Argentina

1231. Daneliya, G. Z., The extension and bending of a tapered built-up girder by a couple (in Georgian), *Trudî Gruz. Politekhn. In-ta* **52,** 4, 135–148, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7865.

The problems of the extension and bending of a tapered built-up girder are examined. By a tapered rod, according to P. M. Riz [see *Izv. Akad. Nauk SSSR Ser. Mat.* no. 4, 1939], is understood a body bounded by a surface $F[x(1 + kz),\ y(1 + ykz)] = 0$ and two planes $z = 0$ and $z = 1$, where k is a small parameter, the squares and higher powers of which are discarded, and y is a constant. The problems posed are reduced by the small parameter method to problems of the deformation of a prismatic bar in the presence of specific volumetric and surface forces. The three-dimensional problems obtained are further reduced to boundary problems relative to the straight built-up region; the solvability of these problems is proved. However, the displacement components plotted do not remain regular when crossing the dividing line between the substances. The author's previous work bore the same title [see *Trudî Gruz. Politekhn. In-ta* **37,** 2, 167–174, 1955]. In this article he examines the case where the materials of which bars are formed have identical Poisson's ratios but different moduli of elasticity. The solution given by P. M. Riz for a homogeneous bar is applied almost unchanged in this case. A. K. Rukhadze

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1232. Mullen, W. G., Lightweight concrete deck for Tappan Zee bridge main spans, *J. Amer. Concr. Inst.* **30,** 6, 685–694, Dec. 1958.

1233. Hiba, Z., Suspension bridge with a hinge in the stiffening girder (in Croation-Serbian), *Naše Gradevinarstvo* **13,** 2, 25–29, Feb. 1959.

Suspension bridges are usually designed on the basis of a statically indeterminate structure, with greater accuracy and economy. Author presents the calculations of a suspension bridge with a hinge at the center of the stiffening girder and compares the results of this simplification with those obtained for suspension bridges having stiffening girders with incomplete flexibility. More thorough study of this subject was published in the author's article "Contribution to the theory of anchored suspension bridges with a center hinge in the stiffening girder" (in German), *Stahlbau* **26,** 11, 348–351, Nov. 1957, and in his report in *Naše Gradevinarstvo* **12,** 3, 57–61, Mar. 1958. J. J. Polivka, USA

1234. Beaton, J. L., Inspection and tests of welding of highway bridges, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 8 (*J. Struct. Div.*), Pap. 1866, 24 pp., Dec. 1958.

1235. Ponomarjov, K. K., Real deformations of vertical cylindrical tanks (in Hungarian), *Magyar Tud. Akad., Musz. Tud. Oszt. Közl.* **23,** 1/2, 111–125, 1958.

1236. Ankudimov, V. N., and Zlatoverkhovnikov, L. F., Calculations for the general stability of hydrotechnical installations by the method of boundary states (in Russian), *Trudi Tsentr. N.-i In-ta Morsk. Flota* no. 12, 40–44, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11590.

Proofs are furnished for the accuracy of the calculations of the general stability of the foundations of hydrotechnical installations using the method of round cylindrical surfaces of slip. The essence of the method consists of the introduction as a criterion of general stability of a coefficient of stability equal to the relation of the moments of force, resisting the upsetting of the installation and the forces upsetting relatively to the center of the arc of slip passing through the foundation. A comparison is furnished between the foregoing method and the method proposed by D. E. Pol'shinyi and R. A. Tokar' ["An approximate graphoanalytical method for calculating the stability of foundations," Mechanics of soils, no. 18, Gos.Izd-vo Lit.po Str-vu i Arkhitekture, 1952].

G. A. Geniev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1237. Karpov, A. B., An experiment in drawing up quadratic formulae for ship constructional calculations (in Russian), *Trudi Nauchno-Tekh. O-va Sudostroit. Promsti* **7**, 2, 183–204, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11196.

Author proposes the introduction of two new quadratic formulas in the practice of ship-constructional calculations. The first, of the type put forward by Chebyshev, takes account of the specific peculiarities of ship-constructional curves. Integration is carried out separately in the region of the cylindrical inset and in the extremities of the ship. Formulas are obtained for the calculations of the areas, the static moments of the areas and cubical contents, the moments of inertia and of the theoretical elements of the ship. The second formula was worked out for application to equidistant ordinates and is a generalized form of Kotes's formula for the case of an arbitrarily located point of contact in the delimiting curve in relation to the abscissa axis. Because of this the necessity does not arise for the introduction into the calculations of reduced or intermediate ordinates. This formula offers the possibility of carrying out the calculations by dividing up the calculation length of the ship into 10 or 20 equal parts. Author illustrates the application of the formula to the calculation of the elements of the areas at waterline level, of the submerged part of the ship's framework, of the displaced water, and of the abscissae and ordinates of the center of pressure.

A. N. Kholodilin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1238. Tryanin, I. I., The determination of the reactions of the transverse bulkheads in a superstructure (in Russian), *Trudi Gor'kovsk. In-ta, Inzh. Vodn. Transp.* no. 14, 3–9, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 8148.

The reactions of transverse bulkheads during the bending of a structure, i.e. the superstructure, whose longitudinal walls do not lie in the same plane as the boards or the longitudinal bulkheads, are determined. Author does not state his assumptions with sufficient clarity, and the impression is created that he is taking the shearing stresses at the point where hull and structure join from calculations made by the method put forward by Yu. A. Shimanskii [The planning of continuous ships' hull joints, 1949], calculations which were made on the assumption that the hull and superstructure curvatures are equal, i.e. only valid for the superstructure. An approximate method is proposed for determining the reactions of bulkheads according to known values of the shearing forces, but this method is acceptable where there are a sufficient number of bulkheads, on which the author places no restrictions.

A. A. Kuradyumov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1239. Korotkin, Ya. I., The strength of the keel's longitudinal ribbing in the presence of cross-bracing (in Russian), *Trudi Tsentr. N.-i In-ta Morsk. Flota* no. 9, 15–21, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 7036.

Formulas are derived for the calculations of stability of two continuous beams, supported on two supports at equal distances apart and joined together in the center of the spans by an undeforming system of cross-bracing; the relation of the compressing forces acting on the beam is taken to be assigned. This problem arose in relation to actual construction of a keel (longitudinal) assembly of a cargo steamer. In addition, formulas were derived for the calculation of the strength of the same system of beams and the question is investigated whether strength or stability leads to the larger dimensions of the profile of the beams.

A. A. Kurdyumov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1240. Rozanov, O. N., Problems of selection of a force-structural scheme of a wing (in Russian), *Trudi Leningrad In-ta Aviats. Priborostr.* no. 14, 13–32, 1956; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 1110.

The coefficient of filling of the cross-sectional area by forcible elements serves as a criterion of estimation. The following wings with duralumin are considered: multiwalled, stringer wing, with easing and with a solid filler. Graphs of the filling coefficient in the function of M/b^3 (M bending moment, b chord) allow one to estimate the utility of the scheme with respect to the value of respective thickness. At small M/b^3 and at large thicknesses the most efficient appears the stringer structure; at large M/b^3 and small thicknesses, wings with a solid filler should be adopted.

Yu. P. Grigor'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Machine Elements and Machine Design

(See Revs. 1129, 1513, 1576)

Fastening and Joining Methods

(See also Revs. 1203, 1209, 1234)

1241. Marin, J., Determination of the creep deflection of a rivet in double shear, *ASME Trans.* **81 E** (*J. Appl. Mech.*), 2, 285–290, June 1959.

An approximate theory is developed for the determination of the creep deflection of a rivet in double shear, on the basis of the creep-stress-time relation in simple tension which includes the elastic, plastic, as well as transient and steady-state creep deformations. The rivet is assumed to be a short beam with fixed ends, and both bending and shear deformations are considered.

Y.-Y. Yu, USA

1242. Rudy, J. F., Suyama, F., and Schwartzbart, H., Welding of reinforcing bars for concrete construction, *Welding J.* **38**, 8, 335s–344s, Aug. 1959.

An investigation of the welding of reinforcing bars has been conducted on random lots, obtained from eleven different suppliers, and representing hard, intermediate and structural grades, in three different bar sizes, embracing a range of chemical composition as follows:

Carbon..... from 0.21% to 0.84%
Manganese .....up to 1.67%
Phosphorus.....up to 0.081%
Sulfur.....up to 0.067%

Although the sampling technique utilized in obtaining the material for this study did include bars from several principal domestic sources and from all reinforcing bar grades, it should be noted that the chemical composition of bars encountered in service may be outside the range investigated herein.

Several geometries of both lap and butt welds were investigated, totaling approximately 550 weldments.

A welding procedure is presented with which strengths up to 75,000 psi to 80,000 psi have been obtained in butt welds on bars of all analyses investigated, except structural grade, where 90% joint efficiency was obtained. These values represent joint efficiencies approaching 100% for intermediate and structural-grade bars, and 60 to 80% for the hard-grade bars, based on the ultimate strength as 100% efficient. If the yield point, which is the figure used for design calculations, is adopted as the basis for joint efficiency, these values run from ~105% for high-grade steels up to ~175% for the intermediate and structural grades.

The procedures involved utilize either E7016 electrodes (70,000 psi ultimate, low hydrogen) or its iron-powder modification. The joint geometries used are conventional, with no preheat requirement. Limited evaluation of the procedure on bars which had been cooled to 0° F indicated no deleterious effects of low temperature.

From authors' summary

1243. Townshend, B., and Porter, E. O., Process welding of nodular and gray-iron castings, *Welding J.* **38,** 8, 329s–334s, Aug. 1959.

Manufacturers of gray or nodular cast-iron parts have been plagued with the "mystery" of the process or repair welding of their products. These materials possess good fluidity, castability, are easily machined and are relatively inexpensive. Unfortunately, castings are not always perfect and occasionally minor design and machining problems arise that have to be corrected. The overall cost of these castings to the consumer may be considerably reduced if satisfactory welding procedures are known and used.

During this investigation particular emphasis was placed on the determination of practicable procedures for welding restrained cast-iron parts.

A test block developed by Schumbacker and Schaeffler was used to evaluate welding procedures. As a result of these tests it was determined that sound welds can be produced in restrained joints of nodular cast iron or gray cast iron using the shielded metal-arc process with the commercially available 55Ni–45Fe electrodes and a preheat temperature of 600 F.

A buttering technique followed by an intermediate heat treatment was found to result in weld joints comparable in strength to the base material.

The most satisfactory technique found for producing welds with a minimum of porosity was one which employed a stringer-bead technique using an arc length of about 3/16 of an inch. A minimum amount of weld penetration is desirable and necessary to obtain porosity-free welds.

From authors' summary

1244. Astrov, E. I., and Chichkanov, A. I., Method of investigating the weldability of metals while subjected to plastic deformation, *Indust. Lab.* **24,** 6, 866–869, June 1959. (Translation of *Zavod. Lab., SSSR* **24,** 6, 768–770, June 1958 by Instrument Society of America, Pittsburgh, Pa.)

Rheology

(See also Revs. 1093, 1101, 1215)

1245. Tomita, Y., A study on non-Newtonian flow in pipe lines, *Bull. JSME* **2,** 5, 10–16, Feb. 1959.

Law of similarity for non-Newtonian fluid flow in pipes is considered, and Fanning's formula concerning pressure losses is extended to cover these fluids. Coefficients of pipe friction for turbulent flow are evaluated and discussed.

G. Power, England

1246. Srivastava, A. C., Rotation of a plane lamina in non-Newtonian fluids, *Bull. Calcutta Math. Soc.* **50,** 2, 57–64, June 1958.

Author extends von Karman's analysis of the rotation of a plane lamina to the one of non-Newtonian fluids satisfying the Reiner relations [*Amer. J. Math.* **67,** 350–362, 1945]. Numerical solutions are obtained by iteration for several values of the parameter $K = \nu_c \Omega/\nu_v$ where ν_c is the kinematic cross-viscosity, ν_v is the kinematic viscosity, and Ω is the angular velocity of the lamina. In addition to the axial flow toward the center of the lamina and the outward radial flow near the lamina found for Newtonian fluids, for sufficiently large values of K for non-Newtonian fluids there appears an inward radial flow at relatively large distances from the lamina.

S. Gratch, USA

1247. Bueche, F., Non-Newtonian viscosity of synthetic rubber and its solutions, *J. Appl. Phys.* **30,** 7, p. 1114 (Letters to the Editor), July 1959.

1248. Serrin, J., The derivation of stress-deformation relations for a Stokesian fluid, *J. Math. Mech.* **8,** 4, 459–469, July 1959.

Investigation of the most general viscosity properties which could be exhibited by a fluid that satisfies certain conditions first indicated by Stokes starts from three precise postulates and proceeds with lemmas and proofs which draw upon tensor analysis and on the theory of matrix invariants. The results are theorems on the "general constitutive equation." Reviewer thinks paper is very clear and found the abstract rigour of author's argument on certain fundamental concepts of hydrodynamics stimulating.

F. C. Roesler, England

1249. Shtchipanov, P. K., The flow of a viscously plastic body in particular peat in the space between two parallel plates (in Russian), *Trudi Mosk. Torf. In-ta* no. 3, 71–80, 1955; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2164.

1250. Mosikhin, E. P., and Vinogradov, G. V., Investigation of mechanical properties of plastic dispersed systems in conditions of uniaxial stretching and compression (in Russian), *Kolloidn. Zh.* **19,** 3, 311–318, 1957; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 1441.

A new method is proposed of investigating rheologic properties of plastic dispersed systems. Two fixtures are described for performing investigations; results of tests are given.

From authors' summary

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1251. Trapeznikov, A. A., Elasticity relaxometer for measurements of highly elastic deformations, strength and relaxation of colloidal systems, *Instruments and Experimental Techniques* no. 3, 423–426, June 1959. (Translation of *Pribory i Tekhnika Eksperimenta, USSR* no. 3, 93–97, May/June 1958 by Instrument Society of America, Pittsburgh, Pa.)

Device (2 models) for measurement of large resilient (highly elastic) shear deformations, up to several thousand per cent, and their relaxation in colloidal systems of relatively fast relaxation

has been developed. The structural strength and the viscosity of the system can also be measured.

From author's summary

Hydraulics

(See also Revs. 1057, 1270, 1271, 1323, 1342, 1343, 1344, 1348, 1522, 1523, 1526)

1252. Vandeperre, L. J., Plisnier, J., and Winand, A., Three fundamental problems of flow of incompressible fluids in pipes or in channels. Parts I and II (in French), *Ann. Trav. Publ. Belgique* no. 4, 5–61, Aug. 1957; no. 5, 53–81, Oct. 1957.

The three fundamental problems of pipe or channel flow

$$h_f = \phi(V \text{ or } Q,\ D \text{ or } R,\ \rho,\ \nu,\ L, \text{ and roughness}),$$

$$V \text{ or } Q = \phi(h_f,\ D \text{ or } R,\ \rho,\ \nu,\ L, \text{ and roughness}), \text{ and}$$

$$D \text{ or } R = \phi(h_f,\ Q,\ \rho,\ \nu,\ L, \text{ and roughness})$$

are presented graphically as

$$f = \phi(\mathfrak{R}),$$

$$f = \phi(\mathfrak{R}\sqrt{f}), \text{ and}$$

$$f = \phi(\mathfrak{R}^2 f).$$

The first two are in common usage. The third relationship for the direct solution of D or R is well known but is unusable (except for smooth pipes) because of the dependence of f upon the relative roughness. The author avoids this problem by using the empirical equation

$$f = 0.00658 + \frac{0.5184}{\sqrt{\mathfrak{R}}}\, c$$

in which c depends only on the boundary material.

Reviewer believes the empirical relationship is incorrect particularly in the hydraulically rough range where f is independent of $\mathfrak{R}$. Even the Swiss and Italian data which the author includes for evaluation of c is functionally quite different than the empirical equation.

M. R. Carstens, USA

1253. Huetz-Aubert, Mrs. J., and Huetz, J., Influence of capillary hysteresis upon the flow of a liquid: The case of oscillations in a U tube: Application to liquid metals (in French), *Publ. Scient. Tech. Min. Air, France* no. 347, 107 pp., Dec. 1958.

Theories which only take account of viscosity are inadequate to describe the flow of certain liquids, and in particular liquid metals, in the presence of a free surface. It is necessary to introduce into the equation of motion a force which can be shown to be proportional to the curve length of the gas–solid–liquid junction and which has its origin in surface tension. Although data concerning physico-chemical properties under dynamic conditions is limited, the application of the complete theory to the case of oscillations in a U-tube leads to satisfactory agreement with experimental measurements of period and damping.

From authors' summary by G. D. S. MacLellan, England

1254. Whan, G. A., and Rothfus, R. R., Characteristics of transition flow between parallel plates, *AIChE J.* **5**, 2, 204–208, June 1959.

Measurements of pressure drop and mean-velocity profile are made in a water duct of 0.7-in. height, 14-in. width and 20-ft length at and around transition Reynolds number.

F. R. Hama, USA

1255. Kaplan, P., and Hu, P. N., The forces acting on slender submerged bodies and body-appendage combinations in oblique waves, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 761–769.

Paper applies slender-body theory to the calculation of forces and moments acting on slender submerged bodies of revolution and body-appendage combinations moving obliquely to crests of regular waves. The main analytical technique used is slender-body theory, which assumes no interaction between the cross-flows in adjacent sections and hence is governed by the two-dimensional Laplace equation in the crossflow plane. Methods for applying slender-body theory to this particular flow problem, which is both time-dependent and spatially nonuniform, are used here to determine all the forces and moments that act upon the body. No consideration is given to the waves created by the body due to its motion near the surface and therefore of the forces that result.

From authors' summary by R. E. Bolz, USA

1256. Zunnunov, N. Z., Equations for the motion of a liquid of variable mass (in Russian), *Dokladi UzSSR* no. 12, 9–11, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11102.

Equations for the motion of a liquid of variable mass lead to the Gromek-Lamb form. It is shown that, as the reactive forces depend on the velocities and not on the coordinates, the assumption, found in the literature, on the existence of a force function of the reactive forces is incorrect.

M. I. Gurevich

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1257. Delleur, J. W., and McManus, D. S., Secondary flow in straight open channels, Proc. Sixth Midwest. Conf. Fluid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 1959, 81–97.

Secondary flows modifying turbulent flow pattern in open channels are analyzed as consisting of a number of helixes similar to observed flow in closed conduits. Reynolds equations in cylindrical coordinates are established. Assuming a uniform helicoidal motion, tangential velocity is independent of abscissa along channel and argument. Also temporal average of radial velocity is zero. Laminar viscous terms are neglected. Turbulent stresses are taken into consideration by use of the apparent stress tensor and its applicable terms, and computed according to Stokes's concept of energy dissipation function, Saint-Venant's stress coefficient and Schlichting's expression for momentum transfer correlations. Equations for turbulent motion are compared to those for laminar motion. Tests made on a 15 ft 7½-in. × 13 $^{11}/_{16}$-in. horizontal flume provided qualitative support for theory since they established the presence of helicoidal flows as assumed. However they failed to agree quantitatively with equations derived from the mathematical model, which is probably over simplified, as stated by authors.

A. Balloffet, USA

1258. Zagrebin, I. S., Investigation of the motion of a liquid in a waterfall in a canal of trapezoidal section (in Russian), *Trudi Kishinevsk. S.-Kh. In-ta* **15**, 43–67, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11139.

Empirical relations evolved on the basis of laboratory results are given; these relations deal with a number of questions on the hydraulics of waterfalls in canals of trapezoidal section. The following points were examined: (1) the distribution of velocities and pressures of the flow at the initial part of the fall; (2) the forms of the free surface in the canal in the "upper" and "lower" waters; (3) the depth at the edge of the fall; (4) the distance from the edge of the fall to the section in which the depth is equal to the critical; (5) the qualitative delineation of the falling current; (6) the value of coefficient φ; (7) the lengths of hydraulic jump at the vertical and sloping walls of the fall; (8) reciprocal depths in the "lower" water.

T. N. Astaficheva

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1259. Chavteraev, A. I., Hydraulics of grids of water-collecting installations (in Russian), *Doklady VASKHNIL* no. 12, 42–44, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11149.

Descriptions are furnished of the results of experimental investigations of the hydraulics of metallic nets, grids made of round rods and rectangular bars set up in front of hydroelectric installations. 34 types were tested with different values for the coefficient of spacing (0.2 to 0.85); 612 tests were made in all. A generalized formula for the coefficient of discharge of the grids, derived by the author, is put forward, as well as a formula for determining the loss of pressure in the grids. Author states that experimental points established by other investigators coincide well with the curves drawn by the method proposed by the author for the generalized relationship. A. M. Latyishenkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1260. Konstantinov, Yu. M., Losses of energy in a stream during drops of rectangular section (in Russian), *Gidrotekhn. i Melior.* no. 8, 46–48, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6662.

On the basis of the results of laboratory and theoretical investigations, carried out by author, on the motion of a flow over a fall, a critical evaluation is put forward of the materials bearing on this question, the materials having been put together by N. G. Dmitrievskii in his paper [*Gidrotekhn. i Melioratsiya* no. 9, 50–55, 1956]. The truth is shown of the inept selection by Dmitrievskii of the section of the flow when examining the question of the losses of energy on the portion of the fall with the application of the equation of quantitative motion, and on some errors and incorrect assumptions adopted by him in deriving the initial equation. A fresh solution is advanced for this question with more successfully selected boundary sections of the isolated sector. An experimental relation is given for the coefficient of velocity reflecting the energy losses in the flow when going over the fall. The value of this coefficient is significantly greater than that given in Dmitrievskii's paper. N. N. Belyashevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1261. Gachechiladze, G. A., A pressure damper of water energy with a perforated diaphragm (in Russian), *Trudi Gruz. N.-i. In-ta Gidrotekh. i. Melior.* no. 18/19, 354–373, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11151.

The theoretical considerations for the hydraulic calculations of a pressure damper with a perforated diaphragm are put forward, the construction being based on analogy with the theory of widening of the free jet in a turbulent flow. Author derives a formula for the determination of the diameter of a cylindrical damping sump, and also the relation of the pressure in the flow under the diaphragm to the height of its position above the bottom. In order to verify the work of the pressure damper and also to enable a selection to be made of the optimum height S for the position of the diaphragm above the bottom, author built a special plant, described in the paper. Recommendations are made, based on the results of the experiments carried out, for the height at which the diaphragm should be situated above the bottom, namely, $0.3\,D_0$, where D_0 is the diameter of the cylindrical damper. Further, recommendations are put forward for the selection of the area of the orifices in the diaphragm and for their distribution. Concluding, the author remarks on the high intensity of dissipation of kinetic energy of flow in the damper and the stability of the regime, of its work at various rates of output, and on the desirability of introducing such dampers into the practice of hydrotechnical construction. A. M. Latyishenkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1262. Shal'nev, K. K., Cavitation in hydrodynamics (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk.* no. 8, 72–116, Aug. 1956.

1263. Cohen, H., and Tu, Y.-O., A comparison of wall effects on supercavitating flows past symmetric bodies in solid wall channels and jets (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles 1957; **2**, 359–370.

1264. Eborovskii, A. A., Strelkov, L. K., Skul'skii, M. K., and Rabinovich, E. I., The hydrodynamics of liquid steel in a mold (in Russian), *Stal'* no. 1, 24–30, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6618.

An investigation, carried out with the help of tagged atoms, of the hydrodynamic phenomena in liquid metal in the process of solidifying in a mould showed that this process is accompanied by intense mixing of the steel, during which the direction of circulation of the flows of the boiling and quiescent steel are not the same. From authors' summary

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Incompressible Flow

(See also Revs. 1040, 1246, 1248, 1252, 1255, 1257, 1318, 1344, 1388, 1430, 1458)

1265. Iida, S., On the eccentric rotation of a circular cylinder in fluid, *Bull. JSME* **2**, 5, 1–9, Feb. 1959.

Author considers circular cylinder in viscous incompressible fluid rotating about its own axis and at same time revolving eccentrically about another fixed axis. Problem is treated as two-dimensional, and approximate solution is obtained for stream function. With obvious restrictions, streamline pattern appears to agree with experiment, except possibly in region where separation occurs. Hydrodynamical forces are also discussed. G. Power, England

1266. Ghildyal, C. D., Steady self-superposable flows of the type curl $q = \lambda q$, *Ganita* **8**, 2, 61–69, Dec. 1957.

Ever since Gromeka (1881) and Beltrami (1889) published their papers on vector fields parallel to their own curls, an extensive literature has been devoted to the usually called Beltrami fields. The present paper discusses the possibility of Beltrami flow for viscous liquids and gives two examples of steady Beltrami flow of nonviscous homogeneous incompressible fluids.

Though we have many papers on Beltrami flow and even some special treatise [Bjørgum & Godal, 1951], the reviewer would welcome a few papers dealing with applications of this flow which would parallel the applications of potential flow to many problems of fluid mechanics. In a bibliographical search on Beltrami flow which the reviewer made two years ago, he was able to find only some vague references to possible applications. E. O. Macagno, USA

1267. Maslen, S. H., On fully developed channel flows: some solutions and limitations, and effects of compressibility, variable properties, and body forces, NACA TN 4319, 42 pp. + 2 tables + 3 figs., Sept. 1958.

Conditions which permit the existence of a fully developed laminar flow in a two-dimensional channel are studied, and a group of exact and approximate solutions for such flows are developed. Fluids considered are (1) an ideal gas and (2) an incompressible liquid with density a linear function of temperature. Effects of variable transport properties, frictional heat generation, and body forces are considered.

Report presents an interesting and thorough analytical study of this type of flows. G. M. Ketchum, USA

1268. Landsbaum, E. M., Thrust of a conical nozzle, *ARS J.* **29,** 3, 212–213 (Tech. Notes), Mar. 1959.

The equations for calculating the thrust of a conical nozzle, originally presented by Malina, are reviewed. The correct use of the equations is demonstrated. The usual improper use of these equations results in a slight error. Although the error is negligible, the correct method should be more widely known.

From author's summary

1269. McManus, H. N., Jr., Film characteristics and dimensions in annular two-phase flow, Proc. 6th Midwest. Conf. Fluid Mech., Austin, Texas, Sept. 1959; Austin, Texas, Univ. Press, 1959, 292–302.

Paper deals with the so-called annular pattern of two-phase horizontal flow, in which a liquid flows on a tube wall as a ring and the gas flows through the central core. Measurements of liquid distribution have been made in a one-inch and a two-inch tube for an air-water system equipped for experiment. The air Reynolds number varied from 59,000 to 285,000; the liquid rates ranged up to 0.6 lb/sec. The entrance film depth measuring device consisted of contact probe and an electric circuit with oscilloscope and d'Arsonval-type microameter; measurements were made of mean and minimum film thickness and maximum wave height at five stations in each tube, the test section length being 17 feet 6 inches.

The profile data presented have shown that appreciable eccentricity of the film exists, and that the wave height is exponentially related to the film depth. The combination of these effects leads to an unequal wall roughness which is appreciable for the air range covered. Author is probably right in believing that these results give an explanation of the indifferent success of the many analytic approaches to the annular flow problem.

A. Ghetti, Italy

1270. Asaturyan, A. Sh., Edigarov, S. G., and Chernikin, V. I., Motion of non-mixing liquids of different specific weight in rectangular open channels (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 7, 115–116, July 1958.

Steady flow of water and crude oil layers in an inclined rectangular channel is discussed. Flow of both liquids is assumed laminar; gravity and viscosity are only factors. Navier-Stokes equations are expanded and approximate solutions obtained. Example shows that conveyance of crude oil over water may be four times greater than without water layer.

S. Kolupaila, USA

1271. Taylor, E. H., Reisman, A., and Ward, J. W., Unsteady flow in conduits with simple surge tanks, *Proc. Amer. Soc. Civ. Engrs.* **85,** HY 2 (*J. Hydr. Div.*), 1–11, Feb. 1959.

The conditions obtained in a simple surge-tank system due to instantaneous and complete load rejection are considered. By introducing a dimensionless parameter into the differential equation attempt has been made to obtain a general solution of the problem. Seventeen curves covering the range of practical interest have been worked out by using the mechanical differential analyzer of the University of California.

P. Franke, Germany

1272. Toomre, A., A pulsating sphere in a rotating fluid, *J. Fluid Mech.* **5,** 4, 571–576, May 1959.

A pulsating sphere, which performs a sequence of virtually impulsive changes in its radius with time, is completely surrounded by an inviscid, incompressible fluid whose velocity field is generally rotational. This paper indicates how it is possible, by means of Helmholtz's theorem, to relate the corresponding vorticity and velocity fields immediately before and after such expansions or contractions.

The method is then applied to the case of a spherical mass of fluid initially in uniform rotation in which a spherical core undergoes a single sudden expansion, followed after a short interval by an equally rapid contraction back to the original radius. An interesting meridional flow is thereby induced, which tends to decrease the angular velocity of rotation of the fluid near the poles at the outer surface, relative to that of the equatorial fluid. It is perhaps significant that this is in qualitative agreement with the variation of angular velocities observed at the surface of the sun.

From author's summary

Compressible Flow (Continuum and Noncontinuum Flow)

(See also Revs. 1054, 1057, 1248, 1305, 1307, 1308, 1313, 1329, 1335, 1336, 1345, 1347, 1350, 1351, 1363, 1383, 1384, 1387, 1460, 1461, 1462, 1463, 1464, 1465, 1466, 1472, 1499, 1500, 1501, 1503, 1508)

1273. Tempelmeyer, K. E., Further note on isentropic compressible flow of air with variable specific heats, *J. Aero/Space Sci.* **26,** 5, 312–313 (Readers' Forum), May 1959.

Author continues his earlier work [*J. Aero. Sci.* **25**, no. 4, 1958] on the variation of specific heat with temperature. $c_p - T$ curve is subdivided into three ranges and an empirical equation is given for each range. Expressions for the Mach number, pressure and density are given in terms of the temperature (T), stagnation temperature (T_t) and stagnation density when T and T_t lie in different ranges. The tabulation should prove useful to workers desirous of including real-gas effects in their work.

S. D. Nigam, India

1274. Ozoklav, H., Flow of a compressible fluid in a hyperbolic channel, *J. Math. Mech.* **8,** 1, 27–46, Jan. 1959.

Analytical investigation is based on reduction of general equations for steady inviscid rotational flow to relations containing only velocity field. For special case of planar flow in which streamlines and orthogonal trajectories form an isometric net, these relations are further reduced to a single partial differential equation for a scalar function of the streamline coordinates. Resulting method is applied to solution, including numerical results, of flow in hyperbolic channel in which all streamlines have shape of confocal hyperbolas and velocity is prescribed on one streamline (which is taken as wall of channel) and one orthogonal trajectory. Possible correspondence of this rotational flow to any physically realizable situation is not discussed.

W. G. Vincenti, USA

1275. Sakurai, A., Three-dimensional steady radial flow of viscous, heat-conducting, compressible fluid, *Quart. J. Mech. Appl. Math.* **11,** 3, 274–289, Aug. 1958.

The case of flow at large Reynolds number is investigated, special attention being paid to the problem of finding deviations from the well-known inviscid flow. The fundamental equations in this case are reduced to a single second-order differential equation of the singular perturbation type, which is quite similar to the corresponding equation obtained in the case of two-dimensional radial flow. Utilizing this similarity and the knowledge obtained from the solution of the two-dimensional case as a guide, the solutions which contain shock waves are studied in detail.

From author's summary by A. Ritter, USA

1276. Diaz, J. B., Two-dimensional flow at high subsonic speeds past wedges in channels with parallel walls, *J. Math. Phys.* **38**, 1, 75–76, Apr. 1959.

In this note the author correctly points out that certain basic formulas deduced by J. B. Helliwell in his article "Two-dimensional flow at high subsonic speeds past wedges in channels with parallel walls" [*J. Fluid Mech.* **3**, 93–109, 1957; AMR **11** (1958), Rev. 2733] and formulas deduced by J. D. Cole in his article "Drag of a finite wedge at high subsonic speeds" [*J. Math. Phys.* **30**, 79–93, 1951; AMR **4** (1951), Rev. 4527] were obtained by A. Weinstein before Cole and Helliwell in Weinstein's articles "Discontinuous integrals and generalized potential theory," [*Trans. Amer. Math. Soc.* **63**, 342–354, 1948] and "Transonic flow and generalized axially symmetric potential theory" [Symposium on theoretical compressible flow, June 1949, Naval Ordnance Laboratory, NOLR-1132, 73–82, 1950].

T. Riabokin, USA

1277. Wood, A. D., and Clarke, J. H., An approximate solution for transonic flow in cascades, *J. Aero/Space Sci.* **26**, 5, 318–319 (Readers' Forum), May 1959.

The small-perturbation, potential equation for steady, isentropic, isoenergetic, transonic flow through an unstaggered, nonlifting, two-dimensional, thin-airfoil cascade is recast as an integral equation by using either Green's theorem or double exponential Fourier transforms. The resulting equation contains a summation of the influence of sources distributed over the entire flow field, whose unknown strength $f(\xi, \eta)$ accounts for the important nonlinear effects when local Mach numbers are near unity. Observing that $\partial/\partial y < \partial/\partial x$ under specified conditions, authors use the approximation $\partial/\partial \eta = 0$ and are able to integrate the resulting exact differential. The approximate solution corresponds to a one-dimensional flow through the cascade.

Calculated minimum pressure coefficients at various Mach numbers are compared with experimental values and theoretical results based on the method of J. R. Spreiter, and those based on linearized subsonic theory and simple one-dimensional approximation. Authors' results appear to be closest to experimental curve, although both authors' and Spreiter's methods follow the experimental trend very well. Experiment was conducted in transonic tunnel by simulating the cascade as images of a single airfoil placed between two solid walls.

T. C. Tsu, USA

1278. Sinnott, C. S., On the flow of a sonic stream past an airfoil surface, *J. Aero/Space Sci.* **26**, 3, 169–175, Mar. 1959.

A semi-empirical procedure is given for the calculation of the pressures on the supersonic portion of an airfoil with a free-stream Mach number near one. The computed example showed good agreement with experiment. The nature of the basis for the present procedure would require further correlations with experiment before conclusions can be made on the validity of the procedure.

H. Yoshihara, USA

1279. Landahl, M. T., Theoretical studies of unsteady transonic flow, Part IV: The oscillating rectangular wing with control surface; Part V: Solution for the delta wing and wings of general polygonal planforms, *Flygtekn. Försöksanst. Rep.* 80, 28 pp., Rep. 81, 22 pp., 1959.

In Part IV the linearized solution of an oscillating rectangular wing is further considered by a method of Schwarzschild [*Math. Ann.* **55**, p. 177–247, 1901] which is essentially a repeated process of finding successive correction terms to satisfy boundary conditions. The method has previously been used in supersonic flow study by Gunn [*Phil. Trans. Roy. Soc. Lond.* (*A*) **240**, p. 327–373, 1947]. The present solution is valid when the ratio of wing span to transverse disturbance wavelength is nonzero.

Part V shows that by means of a transformation from Brill's theorem on linear partial differential equations, solutions of oscillating delta wings are obtainable from those of corresponding rectangular wings. For wings of polygonal planforms, solutions may be obtained by use of repeated lift-cancellations and/or upwash cancellation.

L. N. Tao, USA

1280. Chow, W. L., On the base pressure resulting from the interaction of a supersonic external stream with a sonic or subsonic jet, *J. Aero/Space Sci.* **26**, 3, 176–180, Mar. 1959.

A two-dimensional body with a blunt base is immersed in a supersonic flow and a jet emerges from an opening in the base. Theoretical method to determine the base pressure is given. For a properly assumed constant pressure in the wake the inviscid flow field pertaining to it gives the general character of the flow. Between the air in the wake and the adjacent air streams turbulent mixing takes place; it can be treated theoretically (except for one empirical constant). It is assumed at this point that the air in the jet and the outside air are isoenergetic (i.e. have the same stagnation temperature). The wake pressure (which had to be assumed originally) is found from a mass balance which takes into account the pumping action due to turbulent mixing. Comparison with experiments shows good agreement.

K. G. Guderley, USA

1281. Margolis, K., and Elliott, Miriam H., Formulas pertinent to the calculation of flow-field effects at supersonic speeds due to wing thickness, NASA Memo 4-3-59L, 26 pp., May 1959.

The supersonic perturbation velocity potential for wings of rectangular planform with biconvex airfoil, delta and modified delta planforms with wedge-type airfoils, taking into account thickness effects, is derived. The closed form solutions obtained are based on the assumptions of small disturbances and constant sound velocity throughout the fluid.

The linearized results obtained are very useful for predicting interference effects and it would be very desirable to compare them with calculations based on other methods and with experimental results.

W. Fiszdon, Poland

1282. Luidens, R. W., and Flaherty, R. J., Analysis and evaluation of supersonic underwing heat addition, NASA Memo 3-17-59E, 55 pp., Apr. 1959.

The heat addition is confined between the fore Mach waves from under the trailing surface of the wing. By linearized theory, a wing at optimum angle of attack may have a range efficiency about twice that of a wing at zero angle of attack.

The more rigorous calculations yield, in practical cases, efficiencies about half those estimated by linear theory. An analysis indicates that distributing the heat addition between the fore waves from the undertrailing portion of the wing is a way of improving the performance.

A comparison of the conventional ramjet plus wing with underwing heat addition when the heat addition is concentrated near the wing shows the ramjet to be superior on a range basis up to Mach number of about 8. The heat distribution under the wing and the assumed ramjet and airframe performance may have a marked effect on this conclusion.

From authors' summary by A. Petroff, USA

1283. Semerchan, A. A., Vereshchagin, L. F., Filler, F. M., and Kuzin, N. N., Distribution of momentum in a continuous liquid jet of supersonic velocity, *Soviet Phys.-Tech. Phys.* **3**, 9, 1894–1903, Apr. 1959. (Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **28**, 9, 2061–2071, Sept. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

As a result of work carried out, the distribution of momentum in a continuous jet of water, issuing from a nozzle with supersonic velocity, was obtained. From the curves of momentum distribution, the boundaries of a free jet of water, moving in an atmos-

phere with supersonic velocity, were determined. The shape of the jet obtained in this fashion agrees with the shape of the jet observed on photographs. Authors established that an increase in the viscosity of the issuing liquid leads to a decrease in the angle of conicity of the jet.

A combination of the method of determining the momentum applied in this work with a satisfactory method of determining the density of the moving medium at different points of the jet makes it possible to find the velocity field and the distribution of kinetic energy in liquid jets of supersonic velocity.

From authors' summary

1284. Oguchi, H., Experimental study on the supersonic flow around blunt-nosed bodies of revolution, *Aero. Res. Inst.*, Tokyo, Rep. no. 341, 25, 1, 18 pp., Mar. 1959.

The flows around several blunt-nosed bodies of revolution were experimentally investigated over the Mach number range from 3.76 to 4.78 at the intermittent blow-down-type supersonic wind tunnel of Aeronautical Research Institute, University of Tokyo. In the present experiment we are concerned with the flow behavior ahead of the bodies so that the interferometric study was primarily made.

The main results are summarized as follows:

(1) The surface pressures referred to the stagnation pressure, shock-wave pattern, sonic-line pattern and flow directions were found to be closely correlated to those found both experimentally and theoretically for the case of the flow with a much higher Mach number than in the present test.

(2) The region with the local Mach number lower than 0.5 was confirmed to spread extensively ahead of the nose.

(3) The shock-wave detachment distance was found to be nearly independent of the nose shape, when referred to the radius of curvature of the shock wave.

(4) For the bodies with the same nose radius, the shock-wave detachment distances were found to be nearly independent of the position of the body shoulders.

From author's summary

1285. Boison, J. C., and Curtiss, H. A., An experimental investigation of blunt body stagnation point velocity gradient, *ARS J.* **29**, 2, 130–135, Feb. 1959.

An experimental investigation of the stagnation point velocity gradient of five axisymmetric spherical-segment shapes ranging in bluntness from concave to the equivalent of hemispherical is reported. The tests were conducted in the California Institute of Technology Jet Propulsion Laboratory 20-in. supersonic wind tunnel at Mach numbers of 2.01, 3.01 and 4.76, and at Reynolds numbers based on body diameter from 1 to 1.5 million. Pressure distributions were obtained to a high degree of accuracy by micromanometer techniques and by the use of numerous pressure orifices. A correlation of stagnation point velocity gradient with a bluntness parameter based on the sonic point coordinates was obtained. Modified Newtonian theory was found to be reasonably accurate for predicting the stagnation velocity gradient of near-hemispherical shapes, but current theories for a truncated cylinder predicted values considerably greater than the experimental results. As a by-product of this investigation, two shock detachment correlations were obtained, one using an effective nose radius parameter to compare bodies of varying bluntness with shock density ratio, and the other using a bluntness parameter to obtain an almost linear variation of shock detachment distance and shock sonic point location. From authors' summary

1286. Carafoli, E., and Mateescu, D., Supersonic flow past a conical wing-body lifting systems (in French), *Acad. Repub. Pop. Romine, Rev. Mecan. Appl.* **4**, 3, 377–390, 1959.

Paper discusses the wing-body interference when both are considered conical. The wing is assumed to be triangular, with subsonic leading edges, and its dimensions are not restricted with respect to the Mach cone. However, the body is assumed to be of reduced dimensions with respect to this cone and the wing and body incidences are admitted sufficiently small so as to make applicable the theory of small disturbances.

The motion past the considered system is resolved into an axial symmetrical one about the conical body and into a motion in which the effect of wing and body incidences is considered. This latter motion constitutes the object of this paper, and authors calculate the axial disturbance velocity with the aid of the lateral disturbance velocity which in its turn is determined by means of a conformal mapping in a conveniently chosen plane. In this plane the problem is reduced to the determination of the motion around a thin triangular wing and a circle.

As an application, the case of a delta wing with conical fuselage is presented. T. Oroveanu, Roumania

1287. Randall, D. G., A technique for improving the predictions of linearized theory on the drag of straight-edged wings, Aero. Res. Counc. Lond. Curr. Pap. 394, 41 pp., 1958.

Author suggests to improve linearized supersonic theory for determining the pressure distribution on a sharp-edged swept wing by fulfilling the tangency condition to a higher approximation near the leading edge. Contrary to linear theory, this method gives finite pressures at the leading edge when the leading edge is sonic or subsonic. It also shows better agreement with experiments for the wave drag in the Mach number region for which the leading edge is near sonic. Although unjustified from a theoretical point of view, the proposed method thus seems to be a practically useful improvement on ordinary linearized supersonic theory.

Reviewer notices that a similar method has been proposed by Cox [AMR **11** (1958), Rev. 1248] for bodies of revolution. For a subsonic edge, the method of van Dyke [AMR **8** (1955), Rev. 1745] is superior since it includes also nonlinear terms in the flow field equations. M. T. Landahl, Sweden

Book—1288. Hayes, W. D., and Probstein, R. F., Hypersonic flow theory, (Applied Mathematics and Mechanics, Vol. 5); New York, Academic Press, Inc., 1959, xiv + 464 pp. $11.50.

Within recent years the attainment of extremely high flight velocities has brought a new field of aerodynamic research into prominence. The new features of "hypersonics" may be of purely aerodynamic nature because the Mach number is high or of a physical or chemical nature because the temperatures are extremely high. The present textbook is restricted to the fundamental concepts of hypersonic flow theory excluding specific material on such aerodynamic subjects as hypersonic flight theory and avoiding also empirical approaches.

In an introductory chapter the general features of hypersonic flow fields are studied and the basic inviscid hypersonic assumptions are developed, including also the additional assumption for linearization. The basic hypersonic assumption $M \to \infty$ leads to the Mach number independence principle of K. Oswatitsch. When the velocity disturbances are small compared with the free-stream velocity (but not necessarily small compared with the free-stream sound velocity) the small-disturbance theory can be applied which is inherently connected with classical hypersonic similitude. Authors follow a development which is suitable for a general inviscid fluid instead of only for a perfect gas, and with which also unsteady flows can be treated. The results of Russian works in this field are considered, too.

The branch of hypersonic flow theory based upon the zero density ratio assumption with the shock layer infinitesimally thin is called Newtonian theory. Although this theory provides at best an extremely rough picture of actual hypersonic flow, it is of interest because it can be considered as zeroth approximation of an expansion in the density ratio. In addition, the methods developed in Newtonian theory suggest analogous methods in more realistic theories. The Newtonian theory is extended by the

authors also to unsteady flow. More general solutions are received with the constant density approximation which is exact in the case of steady flow on a wedge, but in other cases implies the restriction that the shock layer be thin. With the latter assumption, also more general problems can be investigated and it is very useful for practical applications that the authors develop the theory of thin shock layers for a fluid obeying a general equation of state (and not only for a perfect fluid with γ near 1 as some other investigators).

The constant-streamtube-area approximation (due to the senior author) for the hypersonic flow on a given blunt body of revolution is extended to the more realistic variable-streamtube-area approximation. Also other methods for the calculation of blunt-body flows are examined, such as streamtube-continuity methods, Dorodnitsyn's method of integral relations and relaxation techniques for the direct problem (body given) and further methods for the inverse problem (shock given). For completely supersonic flow fields the method of characteristics delivers an exact numerical determination. In the present book the method is not restricted to a perfect gas of constant γ. A less laborious technique for finding approximate hypersonic flow solutions for two-dimensional sharp-nosed airfoils with attached shock is the shock expansion method first used by Epstein. The applicability of this method is studied thoroughly.

In the concluding chapters the influence of viscosity and rarefaction on hypersonic flow is investigated. The viscosity effects are essential in the boundary layer, the equations of which are deduced. They are reduced to ordinary differential equations for the case of "similar" laminar boundary layers. The following categories of equilibrium similar solutions are considered in detail: constant pressure solutions, stagnation point solutions, hypersonic solutions and solutions with $Pr = 1$ and, as additional category, the "frozen" solutions. Also more general methods like integral methods or series expansion methods are considered and also turbulent boundary layers are taken into account. In hypersonics the viscous interaction of the shock wave and the boundary layer is very important and existing theories on the weak and strong pressure and on the vorticity interaction are considered in detail. The general features of rarefied gas flows are developed and a classification of flow regimes from continuum flow at high Reynolds numbers to free molecule flows at extremely low Reynolds numbers is suggested.

The present book was originally projected as a contribution to "Advances in applied mechanics," and we must congratulate the authors that, at the suggestion of Th. v. Kármán, they have transformed a short review paper into an excellent and comprehensive textbook. W. Wuest, Germany

1289. Vas, I. E., and Bogdonoff, S. M., Hypersonic studies of blunt unswept wings, WADC TN 59-127 (Princeton Univ., Dept. Aero. Engng. Rep. 450; ASTIA AD 214 623), 74 pp., Apr. 1959.

The pressure distributions and shock shapes of two-dimensional unswept blunt hypersonic surfaces have been investigated in the helium tunnel at Mach numbers between 11 and 19 and angles of attack of $\pm 10°$. The tests were in a region of leading edge thickness (Re_+ 2000) where the pressure distributions were primarily determined by the inviscid flow. The pressure dependence was found to be a function of M^n and (s/t) to the exponent -0.57 for tests in the conical nozzles, and -0.60 for $M = 11.6$ tests in a uniform flow nozzle. A simple correlation of all results for the Mach number and angle-of-attack range was found. The effect of leading edge shape was also investigated. Further work at high Mach number is still needed to completely evaluate leading-edge Reynolds number effects and conical versus uniform flow nozzle studies.

From authors' summary

1290. Romig, Mary F., Application of the hypersonic similarity rule to conical flow of dissociated air, *Aero/Space Engng.* **18**, 3, 56-59, Mar. 1959.

Numerical solutions of the Taylor-Maccoll equations have been obtained for a variety of cone semivertex angles, ambient pressures, and flight velocities. A hypersonic similarity parameter permits correlation of these solutions with less than 1 per cent error. From author's summary

1291. Vinokur, M., Inviscid hypersonic flow around blunt bodies, Lockheed Missiles & Space Div., TN 48454, 47 pp., Mar. 1959.

The inviscid supersonic blunt body problem is considered. The flow in the subsonic region is treated by neglecting variations in density. If the shock curvature is assumed constant near the axis, an approximate analytic solution can be obtained for an arbitrary body shape. As an illustration, the method is carried out for oblate ellipsoidal noses. This shape is of particular interest since it includes flat-faced and spherical bodies in a one-parameter family. The solution reduces to that of Lighthill for a sphere. The results are compared with those of other theories, as well as with available experimental data. Also indicated is the improvement of the solution to take into account variations in density and shock curvature. From author's summary

1292. Whitham, G. B., A new approach to problems of shock dynamics, Part II: Three-dimensional problems, *J. Fluid Mech.* **5**, 3, 369-386, Apr. 1959.

This is an extension of a previous paper on two-dimensional problems. The main ideas of finding the shock shape and position as a function of time are developed and applied to shock diffraction by a cone and a slender body. The method is capable of solving a wide variety of shock motion problems by use of the well-developed methods of linearized supersonic flow. Characteristics and perturbation methods are discussed. In the former, the intersection of characteristics gives rise to shock-shocks which are to be interpreted as Mach reflections.

H. W. Emmons, USA

1293. Otterman, J., Finite-amplitude propagation effect on shock-wave travel times from explosions at high altitudes, *J. Acoust. Soc. Amer.* **31**, 4, 470-474, Apr. 1959.

A method is described for calculating the effect of the finite-amplitude propagation on the travel times of pressure waves from explosions at high altitudes to the ground. Numerical results are presented for explosions of 2-lb and 4-lb H. E. charges at altitudes ranging from 15 to 95 km. Vertical propagation is assumed in the calculations. This work has been carried out in order to improve the systematic accuracy of the rocket grenade experiment for upper atmosphere temperature and winds. The significance of the finite-amplitude propagation in this experiment is discussed.

From author's summary

1294. Gustafson, W. A., Aerodynamic moment on bodies moving at high speed in the upper atmosphere, *ARS J.* **29**, 4, 301-303 (Tech. Notes), Apr. 1959.

Analytical expressions are presented for the moments on a cylindrical body, a cone frustum, and a spherical segment in free molecule flow. It is assumed that free-stream particles strike the surface and give up their total momentum and that atmospheric particles leave the surface with a Maxwellian distribution corresponding to the surface temperature. This temperature is determined by a thermal radiation analysis.

G. E. Nitzberg, USA

1295. Liu, V. C., On pitot pressure in an almost-free-molecule flow—A physical theory for rarefied-gas flows, *J. Aero./Space Sci.* **25**, 12, 779-785, Dec. 1958.

A physical theory of pitot pressure in the transition-flow regime is proposed. The ratio of the mean free path to the radius of the cavity opening is assumed to be of the order unity or larger. A

general formula for the perturbation to the pitot pressure in the free-molecular flow is given. This perturbation is attributed to the intermolecular collisions, which are neglected on the basis of the free-molecule hypothesis. The expected rate of collision is calculated for rigid spheres, using the classical kinetic theory.

Although this is intended as an approximate theory, the theoretical results agree surprisingly well with the limited experimental data that are available. The present theory shows that ratio of Reynolds number to Mach number is the governing parameter for determining the intermolecular-collision effect on pitot pressure in the transition-flow regime.

From author's summary by H. Lin, USA

1296. Mirels, H., Source distribution method for unsteady one-dimensional flows with small mass, momentum, and heat addition and small area variation, NASA Memo 5-4-59E, 49 pp., June 1959.

New analytical method for treating nearly one-dimensional compressible flows uses concept of sources rather than more familiar method of characteristics. Author claims somewhat greater physical insight results from use of this approach. Examples of several shock-tube flows are included. W. C. Griffith, USA

1297. Frankl', F. I., Potential steady relativistic gas flows, *Soviet Phys.-Doklady* **3,** 6, 1110-1112, June 1958. (Translation of *Doklady Akad. Nauk SSSR (N.S.)* **123,** 1, 47-48, Nov. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

This paper represents a continuation of the studies of relativistic fluid mechanics. The previous work was on one-dimensional flow and proof that the flow of frictionless non-conducting gases as relativistic gases can be governed by a velocity potential. In this latest publication the steady potential flow is studied.

In the opinion of the reviewer the most interesting result is that the apparent ratio of specific heats is two for flows with relativistic velocity and finite temperature. This flow is easily simulated by the surface waves in a water-table flow which is analogous to a flow with a ratio of specific heats of two.

E. E. Covert, USA

Boundary Layer

(See also Revs. 1254, 1288, 1296, 1319, 1349, 1381, 1382, 1392, 1400, 1402, 1427, 1467)

1298. Rott, N., and Lenard, M., Vorticity effect on the stagnation-point flow of a viscous incompressible fluid, *J. Aero/Space Sci.* **26,** 8, 542-543 (Readers' Forum), Aug. 1959.

Starting with an exact solution of the Navier-Stokes equations for external rotational flow and the stagnation-point boundary-layer solution, authors show by a perturbation analysis that the effect of vorticity in the external flow is of the same order of magnitude as the curvature effect, the displacement effect and the slip effect for axisymmetric flow. The vorticity is, however, negligible for a two-dimensional flow. Result agrees exactly with a similar analysis by Kemp in the same issue of this journal, p. 543. More detail is promised in a forthcoming report. R. E. Street, USA

1299. Lunev, V. V., The method of small disturbances in problems of the laminar boundary layer (in Russian), Avtoref. Diss. Kand. Fiz.-Matem. Nauk, MGU, Moscow, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5468.

1300. Sandborn, V. A., An equation for the mean velocity distribution of boundary layers, NASA Memo 2-5-59E, 47 pp., Feb. 1959.

Purpose of the paper is to establish with empirical methods a general relation to represent laminar and turbulent velocity profiles for incompressible boundary-layer flow. Author uses a polynomial with two separate power terms and four constants which are related to the displacement and momentum thickness of the boundary layer and the shear stress parameter at the wall. He shows how to fit given experimental data with the proposed equation and how to compute any turbulent profile if the basic parameters are given. A criterion to predict turbulent separation is derived. Theoretical results are compared with measured velocity distributions and show, in general, good agreement.

K. Pohlhausen, USA

1301. Turner, T. R., Davenport, E. E., and Riebe, J. M., Low-speed investigation of blowing from nacelles mounted inboard and on the upper surface of an aspect-ratio-7.0 35° swept wing with fuselage and various tail arrangements, NASA Memo 5-1-59L, 42 pp., June 1959.

An investigation of inboard jet flaps on a semispan model, representative of current jet transport airplanes, has been made in the Langley 300-MPH 7- by 10-ft tunnel. The jet momentum-coefficient range was from 0 to 7.0 and the model angle-of-attack range was from about $-14°$ to about $30°$.

From authors' summary

1302. Stratford, B. S., The prediction of separation of the turbulent boundary layer, *J. Fluid Mech.* **5,** 1, 1-16, Jan. 1959.

A criterion is derived for estimating the separation point in a two-dimensional turbulent boundary layer. Derivation assumes that boundary layer in neighborhood of a separation point consists of an outer region in which the head losses due to shear stresses are the same as for a flat plate in zero pressure gradient, and an inner layer in which the inertia forces are negligible and the motion depends on the normal derivative of the shear stress at the wall and the kinematic viscosity. It is then shown, both by means of mixing-length theory and by obscure dimensional arguments, that the velocity distribution near the wall varies as the square root of the product of the pressure gradient by the distance from the wall. The condition of continuity of the stream function and of the transverse gradient of the tangential velocity component and the assumption of a power law for the velocity distribution at the juncture of the inner and outer layers yield a separation criterion, expressed in terms of the pressure coefficient and its longitudinal gradient, the exponent of the power law, an "equivalent" distance x from the leading edge, the Reynolds number based on x and an undetermined "constant" which depends upon the second normal derivative of the pressure. The theory is developed for a turbulent boundary layer with pressure distribution of zero gradient up to a point x_0 beyond which the gradient suddenly becomes adverse. It is applied to cases with initially laminar boundary layer, transition, and favorable pressure gradient on the basis of the assumption that the distance from the leading edge to the point of peak velocity in the actual case is "equivalent" to a distance x_0 for the turbulent boundary layer in zero pressure gradient at which the momentum thicknesses are equal. Tests of the criterion indicate that its predicted separation points x are low, with an error up to 10%.

In reviewer's opinion, the criterion, which is based on more than the usual number of first-order approximations and assumptions typical of turbulent boundary-layer theory, is more accurate than might have been expected. Since its application requires knowledge of actual pressure distribution even when separation is occurring, and of the transition point, reviewer cannot agree with the author that criterion is convenient to apply.

L. Landweber, USA

1303. Stratford, B. S., An experimental flow with zero skin friction throughout its region of pressure rise, *J. Fluid Mech.* **5,** 1, 17-35, Jan. 1959.

In order to confirm the theory of the previous paper and to evaluate an undetermined factor of the separation criterion resulting

from the theory, a flow with effectively zero shear stress at the wall throughout the region of pressure rise, which was consequently on the verge of separation throughout the region, was produced and investigated. The desired flow, which was obtained in an open return wind tunnel without fundamental difficulty, was stable and appeared to provide the shortest possible distance for a given pressure rise.

It was found that with a particular choice of the aforementioned undetermined factor the experimental and predicted pressure distributions were in excellent agreement. The theoretical result that velocity near the wall varies as the square root of the normal distance was verified for sections close to the start of the zone of adverse pressure gradient; but it appears to the reviewer that farther downstream the predicted variation, which, in the derivation of the separation criterion, had been assumed to extend as far as the outer region of the boundary layer, occurred only in a very small neighborhood of the wall, or not at all.

L. Landweber, USA

1304. Howe, J. T., and Mersman, W. A., Solutions of the laminar compressible boundary-layer equations with transpiration which are applicable to the stagnation regions of axisymmetric blunt bodies, NASA TN D-12, 73 pp., Aug. 1959.

By making the simplifying assumptions that (1) the local Mach number is small, (2) the Euler number times $\partial P/\partial x/\rho_e u_e^2$ is constant, (3) the wall temperature is constant, (4) the fluid properties are proportional to a power of the temperature, the partial differential equations for the laminar boundary layer at a stagnation point are reduced to ordinary differential equations. These are integrated numerically in a high-speed machine for 15 cases differing in wall temperature and transpiration rate for $Pr = 0.7$ and $En = 1/3$, and the solutions are tabulated.

It is found that transpiration gives a large reduction in skin friction and heat transfer.

W. Squire, USA

1305. Tetervin, N., Charts and tables for estimating the stability of the compressible laminar boundary layer with heat transfer and arbitrary pressure gradient, NASA Memo 5-4-59L, 48 pp., May 1959.

Using Lin's rapid approximate method for two-dimensional disturbances, author has calculated the minimum critical Reynolds numbers $R_{\theta,c}$ based on momentum thickness for a set of boundary-layer solutions, especially the similar solutions of Cohen and Reshotko [NACA Rep. 1293]. Results are presented in tables and figures for various values of a pressure gradient parameter β, a surface enthalpy parameter S_w, and the local Mach number M_e at the edge of the boundary layer (M_e ranges from 0 to 2.8). Mach numbers ($M_{e,\infty}$) for complete stabilization ($R_{\theta,c} = \infty$) are also calculated. It is shown that for zero wall temperature ($S_w = -1$), $R_{\theta,c}$ becomes infinite for all M_e.

Reviewer had previously found and discussed [NACA TN 4037] the unexpected result that in low-speed ($M_e = 0$) flow over a highly cooled wall (with zero or small rates of mass-flow injection) $R_{\theta,c}$ is less for a stagnation flow ($\beta = 1$) than for a flat-plate flow ($\beta = 0$). This destablizing influence of a favorable pressure gradient in the case of a highly cooled wall is again encountered here. Thus, it is found that for $S_w = -0.8$, $R_{\theta,c}$ decreases with an increase in β for all M_e below $M_{e,\infty}$. The critical Reynolds numbers in these cases, however, are again found to be higher than any boundary-layer Reynolds numbers likely to be met in practice. Author states that "calculations for values of M_e up to 8 show that, for values of M_e greater than $M_{e,\infty}$, an increase in β increases $R_{\theta,c}$, the usual effect."

M. Morduchow, USA

1306. Howe, J. T., Some finite difference solutions of the laminar compressible boundary layer showing the effects of upstream transpiration cooling, NASA Memo 2-26-59A, 33 pp., Feb. 1959.

The finite difference method developed by Flügge-Lotz and coworkers for the solution of laminar boundary-layer problems is applied to cited problems. Results are compared to approximate solutions and permit separation of heat-sink and mass-addition effects of partial injection; latter effect is found to predominate. Reviewer notes that at junction of permeable and solid surfaces the boundary-layer equations are not applicable and that even "exact" (i.e., finite difference) solutions to these equations are invalid.

P. A. Libby, USA

1307. Michel, R., Practical calculations of compressible turbulent boundary layer: Principles and applications (in French), *ONERA NT* 49, 33 pp., Jan. 1959.

Paper presents a quadrature solution of the boundary-layer integral momentum equation for two-dimensional and for axially symmetric compressible turbulent boundary layers. Reduction to quadrature is effected by relating the incompressible skin-friction coefficient to the momentum thickness Reynolds number, using simple approximate equations to give the effect of Mach number on the skin-friction coefficient and on the boundary-layer shape factor (ratio of displacement thickness to momentum thickness), and using a mean value of the equivalent incompressible shape factor in performing the required integrations. Tables of appropriate functions of Mach number in the flow outside the boundary layer are given to facilitate numerical calculations. Some sample calculations are presented, and the possibility of calculating the effect of the boundary layer on the outer flow is discussed.

A similar study has been made by Culick and Hill [*J. Aero. Sci.* **25**, 4, p. 259, 1958; AMR **12** (1959), Rev. 312] who applied a modified Stewartson-Illingworth transformation to Truckenbrodt's quadrature formula for incompressible turbulent boundary layers [NACA TM 1379]. The quadrature formulas of Michel and of Culick and Hill are similar, but not identical, embodying slightly different approximations; the reviewer has not compared them numerically.

I. Greber, USA

1308. Kistler, A. L., Fluctuation measurements in a supersonic turbulent boundary layer, *Physics of Fluids* **2**, 3, 290–296, May–June 1959.

Measurements of mean and fluctuating point properties were made in a thick boundary layer of a supersonic wind tunnel. Mach numbers of 1.72, 3.56 and 4.67, at a momentum thickness Reynolds number of 30,000, were studied. Total pressure was measured with a stagnation tube and mean total temperature with a resistance thermometer. Fluctuating quantities were determined with hot-wire apparatus operating at different temperatures. The results demonstrated that the mean velocity follows the "law of the wall", as would be expected with no measurable Mach number influence. Applying the assumption that the contribution of the pressure fluctuations to the hot-wire signal is negligible, the absolute levels of velocity and temperature fluctuations are specified. It is found that the temperature fluctuation levels at various Mach numbers are proportional to the mean temperature difference across the boundary layer. The velocity fluctuations divided by the friction velocity fall off slowly with Mach number. It is postulated that the mechanism for producing the temperature fluctuations is the convection of the mean temperature field by the velocity fluctuations.

W. D. Baines, Canada

1309. Sutton, G. W., Combustion of a gas injected into a hypersonic boundary layer, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 539–545.

Effects of injection of a combustible coolant gas into a hypersonic boundary layer are studied by solving boundary-layer equations at a stagnation point. When a combustible gas is used, the

mass-transfer rate required to maintain a given wall temperature is greater than for a noncombustible gas. The percentage increase becomes smaller, however, as the required wall temperature decreases. T. Y. Toong, USA

1310. Glauert, M. B., A boundary layer theorem, with applications to rotating cylinders, *J. Fluid Mech.* **2,** 1, 89–99, Jan. 1957.

1311. Smith, A. M. O., and Clutter, D. W., The smallest height of roughness capable of affecting boundary-layer transition, *J. Aero/Space Sci.* **26,** 4, 229–245, Apr. 1959.

Authors describe experimental investigation in a low-speed wind tunnel of critical heights of three types of roughness: spanwise wires, three-dimensional disks, and sandpaper. Other variables are pressure distribution, tunnel turbulence, and run of laminar flow. Data are correlated on basis of roughness Reynolds number based on roughness height and flow properties at that height. Critical Reynolds number is independent of test variables except shape of roughness. Available data on critical roughness in supersonic flow indicate correlation with roughness Reynolds number. Reviewer suggests comparison of results with those of Braslow and Knox, AMR **12** (1959), Rev. 2499.

W. F. Davis, USA

1312. Curle, N., and Skan, S. W., Approximate methods for predicting separation properties of laminar boundary layers, *Aero. Quart.* **8,** 257–268, Aug. 1957.

1313. Evvard, J. C., Transition studies on blunted bodies at supersonic speeds (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **4,** 94–102.

Turbulence

(See also Revs. 1257, 1280, 1302, 1303, 1307, 1311, 1418, 1442)

1314. Sitnikov, K. A., Invariants of homogeneous isotropic turbulence in a compressible viscous fluid, *Soviet Phys.-Doklady* **3,** 5, 911–914, May 1959. (Translation of *Dokladi Akad. Nauk SSSR (N. S.)* **122,** 1, 29–32, Sept. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Author points out that, since the formal expressions for the rates of change of mass, momentum and energy per unit volume of a compressible fluid are vector divergences, the integral overall space of the spatial covariance of fluctuations in any two, or of the spatial correlation for fluctuations in any one, of these three quantities (mass, momentum, energy) is invariant with respect to time. For these results it is assumed that all relevant covariances fall off more rapidly than as r^{-2}, as the separation r approaches infinity.

Author remarks in passing that objections which have been raised against the Loitsianski invariant [AMR **9** (1956), Rev. 3699] do not apply when the fluid has some degree of compressibility, however small; in this I believe he is mistaken, although the paper under review may not be affected.

The author gives laws for decay of various quantities (mean-square density fluctuation, etc.) in the final period of decay when all nonlinear terms in the governing equations are negligible, with allowance for the effects of thermal conductivity and two kinds of viscosity. G. K. Batchelor, England

1315. Reid, W. H., and Harris, O. L., Similarity spectra in isotropic turbulence, *Physics of Fluids* **2,** 2, 139–146, Mar.–Apr. 1959.

Authors calculate similarity solutions related to the energy spectrum of turbulence according to the transfer hypothesis of Kovasznay. For the initial period of delay an exact analytical formula is found, but numerical calculations are also given. Similarity in the final period is also treated.

Results are similar to those obtained by Chandrasekhar [*Proc. Roy. Soc. Lond.* (*A*) **200,** p. 20, 1949; AMR **3** (1950), Rev. 347] and Proudman [*Proc. Camb. Phil. Soc.* **47,** p. 158, 1951; AMR **4** (1951), Rev. 2614] for the similarity hypothesis of Heisenberg.

J. T. Stuart, England

1316. Pearson, J. R. A., The effect of uniform distortion on weak homogeneous turbulence, *J. Fluid Mech.* **5,** 2, 274–288, Feb. 1959.

Paper deals with the behavior of weak homogeneous turbulence subject to a uniform distortion. Mathematical analysis is carried out in terms of the energy spectrum tensors, equation for which is derived from the equations of motion by neglecting the second-order terms with respect to the intensity of turbulence.

Three particular types of distortion are discussed: uniform rotation, uniform shear, and uniform irrotational distortion. Only short comments are given for the first two cases, and it is suggested that the total energy of turbulence decays with time. For the third case it is found that the total energy increases indefinitely with time, and detailed discussions for this case are presented. Numerical solutions are obtained for the case of axisymmetric extension of a weak turbulence which was initially isotropic.

Although the scope of this paper is limited to some linear aspects of the interaction between the turbulence and the mean velocity field, the results obtained seem to furnish us with suggestive insight into the interesting and yet unsolved problem of the shear flow turbulence. S. Tomotika, Japan

1317. Blanch, Gertrude, and Ferguson, H., Remarks on Chandrasekhar's results relating to Heisenberg's theory of turbulence, *Physics of Fluids* **2,** 1, 79–84, Jan.–Feb. 1959.

Authors give improved numerical results for the spectrum of turbulence, following Chandrasekhar's work [*Proc. Roy. Soc. Lond.* (A) **200,** p. 20, 1949; AMR **3** (1950), Rev. 347] on the consequences of Heisenberg's transfer hypothesis.

J. T. Stuart, England

1318. Robertson, J. M., On turbulent plane-Couette flow, Proc. 6th Midwest. Conf. Fluid Mech., Austin, Texas, Sept. 1959; Austin, Texas, Univ. Press, 1959, 169–182.

The prediction of temporal-mean velocity profile for plane-Couette flow of a turbulent type, made by various students after the von Kármán pioneer work of 1937, could not be ascertained for a long time because of experimental results. In 1955, Reichardt, and in 1958 the author, studied this flow in a belt-type apparatus. The essential difference between the two is that Reichardt's apparatus had both planes moving, while that of the author had one fixed wall and one moving. Kinematically the difference is only of relative motion, but experimentally it is considerable.

The analytical solutions consisting of core and wall-law portions show good agreement with experimental measurements. The proper skin-friction coefficient relation appears to be close to that of Reichardt's analysis. But Reichardt's profile solution does not agree well, while other profile solutions are generally in poor agreement, with observation. An "a priori" solution by the author is in need of adjustment of constants; the mixing length scales found appropriate in other flows are probably to be modified to agree better with experiments. The study of this interesting and novel flow situation should be developed on a wider range of Reynolds numbers ($1.65 \cdot 10^4$ being the maximum experienced by the author) to give more consistent hypothesis on the turbulent model to be assumed. A. Ghetti, Italy

1319. Poreh, M., and Cermak, J. E., Flow characteristics of a circular submerged jet impinging normally on a smooth boundary, Proc. Sixth Midwest. Conf. Fluid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 1959, 198–212

At distance b between nozzle and deflecting plate, for instance much greater than ten nozzle diameters, three main zones can be distinguished. Up to about 0.8 b, the jet behaves as if it were issuing in an unconfined space. Then a deflection zone occurs followed by a zone of established radial flow along the plate ($r > 0.3\ b$). Velocity distributions in the three zones and pressure distributions at the plate wall have been measured. The velocity distribution measured in the first zone agrees reasonably well with the Gaussian error curve as well as with the theoretical distribution based upon a constant eddy viscosity. The flow in the deflection zone, at least near the stagnation point, appears to follow closely the one computed on the assumption of irrotational flow.

In the radial zone along the plate the flow is a boundary-layer flow whose outer region resembles that of an unconfined radial jet with a velocity distribution described satisfactorily by a Gaussian curve as well as by a theory assuming a constant eddy viscosity and a uniform pressure distribution; the measured radial pressure-gradient was about zero. A theory describing the velocity distribution in the inner region of the boundary layer is proposed.

J. O. Hinze, Holland

1320. Khazen, A. M., A universal instrument for research into turbulence in nonsteady gas flows (in Russian), *Sb. Statei Nauchn. Stud. O-va Mosk. Energ. In-ta* no. 10, 53–71, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7767.

A description is given of an installation for measuring the intensity of turbulence by glow discharge. Although glow discharge has more than once been suggested for the measurement of turbulence [C. Lindwall, *Electr. Engng.* no. 7, 1934; Yu.G. Zakharov, *Zh. Tekh. Fiz.* **9**, no. 21, 1939], it has not been used up to the present owing to the insufficient stability of its characteristics. The theory of the instrument and the selection of the discharge stability conditions are given. The instrument constructed by the author consists of a 6-mm diameter glass rod; the working section of the sonde is 3–5 mm long and 1 mm wide; the frequency range is 2–100 kc/s. Measurements can be made by oscillograph and by thermo-amperemeter (for measuring the root-mean-square velocity pulsations). In order to investigate the rotary break away and the coefficient of correlation of the turbulence components of the velocity at two points, the instrument is made in two-channel form. Pulsation oscillograms taken with this instrument in various flows are given. The instrument is of small dimensions and is characterized by its universal applicability; it is suitable for many aerodynamic experiments, and in the author's opinion is about twenty times cheaper than a thermo-amperemeter with the same frequency range.

E. M. Minskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1321. Zalishauskas, M. P., Investigation of the turbulent rarefaction applicable to jet apparatus (in Russian), Avtoref. Diss. Kand. Tekhn. Nauk Belorussk. Politekhn. In-ta, Minsk, 1957; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 530.

1322. Bakharev, V. A., Motion of a liquid in the free and compressed turbulent stream (in Russian), *Trudi Nauchn. Sessii. Vses. N.-i. In-ta Okhrany Truda* no. 4, 8–22, 1955; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 831.

An attempt is made to formulate a theory for spreading of the turbulent stream in the stationary medium, based on an assumption of instability in the quantity of the liquid flowing along the stream and that some closed circulating motion inside the stream exists and, consequently, that the stream hav curve-lined limits.

It should be noticed that the author's assumptions refute the experimental evidence [see, for example, G. N. Abramovich, "Turbulent free streams of liquids and gases," Gosenergoizdat, Moscow-Leningrad, 1948 or M. L. Albertson, *Proc. Amer. Soc. Civ. Engrs.* 1948, **7**, 1571–1596] which confirms the plan of flow continuity in the stream and its linear limits.

Apart from that, the experimental results of Albertson determine the existence of cross sections of the plane parallel stream at the distance of 1000 times the pipe diameter from the outlet, while the Bakharev calculations show that at this distance the stream should be already closed.

Apart from these fundamental hypotheses there are several assumptions which evoke doubts. The author, for example, assumes that the intensity of the turbulence drops to zero at the stream axis, while it is known that this magnitude has a finite value at the axis [see, for example, S. Corrsin, M. S. Uberoi, *NACA Rept.* 998 (1950)].

O. V. Yakovlevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1323. Elder, J. W., The dispersion of marked fluid in turbulent shear flow, *J. Fluid Mech.* **5**, 4, 544–560, May 1959.

Following work by G. I. Taylor on the longitudinal spreading of marked fluid in turbulent flow with unidirectional mean velocity, author calculates the longitudinal diffusivity for the flow of water of depth h in a broad open channel to be $5.9\ u_\tau h$, where u_τ is the wall friction velocity. Author's observations of the distribution of mean concentration of dye at various times after release of a single drop in an open channel of depth about 1 cm are shown to be in reasonable agreement with the calculation, provided the part of the concentration distribution which is affected by the viscous sublayer is ignored. Taylor's method is also used to calculate the longitudinal dispersion of small solid spheres in turbulent flow in a pipe, account being taken of the inaccessibility of the outer annular region of the fluid and of small differences between the densities of the water and the spheres. The agreement here with observations reported earlier is fair, and is presumably limited by the effect of the viscous sublayer (ignored in the calculation) on spheres of small diameter; whereas in observations of the spreading of dye it is possible to see approximately the separate effects of the turbulent core and the viscous sublayer, the observations of dispersion of solid spheres were not such as to allow a separation.

A stimulating paper, worthy of close study.

G. K. Batchelor, England

1324. Mills, R. R., Jr., and Corrsin, S., Effect of contraction on turbulence and temperature fluctuations generated by a warm grid, NASA Memo 5-5-59W, 58 pp., May 1959.

Hot-wire anemometer measurements were made of several statistical properties of approximately homogeneous and isotropic fields of turbulence and temperature fluctuations generated by a warm grid in a uniform airstream sent through a 4-to-1 contraction. These measurements were made both in the contraction and in the axisymmetric domain farther downstream.

In addition to confirming the well-known turbulence anisotropy induced by strain, the data show effects on the skewness of both longitudinal velocity fluctuation (which has zero skewness in isotropic turbulence) and its derivative. The concomitant anisotropy in the temperature field accelerates the decay of temperature fluctuations.

From authors' summary by C. E. Carver, Jr., USA

1325. Kolar, V., The effect of a secondary flow on turbulence, Proc. 3rd. Congr. Theor. Appl. Mech., Bangalore, India; Kharagpur, Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., 1957; 193–198.

1326. Kolar, V., Turbulence in spiral flow of water, Proc. 2nd Congr. Theor. Appl. Mech., New Delhi, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1956, 127–130.

1327. McManus, H. N., Jr., Effect of unequal wall roughness on flow between flat plates, *ARS J.* **29**, 2, 144–145 (Tech. Notes), Feb. 1959.

Aerodynamics

(See also Revs. 1075, 1076, 1274, 1277, 1278, 1279, 1280, 1281, 1286, 1289, 1301, 1307, 1311, 1350, 1353, 1354, 1357, 1381, 1383, 1461, 1495)

1328. Dryden, H. L., Current problems in aerodynamic problems research (in German), *Z. Flugwiss.* **6**, 8, 217–233, Aug. 1958.

The influence and spirit of Ludwig Prandtl are evident in aeronautics today. Even in a large organization such as the National Advisory Committee for Aeronautics (NACA) a place can be found for creative and gifted men to work in a free and independent manner on fundamental problems in which they are interested. Many others are inspired to attack important problems in Prandtl's way, by devising simple conceptual models which include the essential physical processes and by testing these models by experiment. In this way the aeronautical world still honors Prandtl and advances knowledge in the sciences he established.

From author's summary by T. P. Torda, USA

1329. General research in flight sciences (Jan. 1958–Jan. 1959), Fluid Mechanics, Vol. II: Inviscid Flows, Lockheed Aircr. Corp., Missiles and Space Div. TR-48381, vii + 163 pp., Jan. 1959.

The seven papers by several authors present approximate methods of determining various aspects of the flow about rotationally symmetric blunt bodies at small angles of attack. The papers are alike in solving analytically or numerically problems that have been simplified by a major physical assumption such as that the density in the subsonic region behind a head shock is constant. They are also alike in providing no bounds on the error due to the simplification. C. M. Ablow, USA

1330. Sauer, R., Introduction to the method of distributions with application to a problem in aerodynamics (in Italian), *R. C. Semin. Mat. Fis.* **28**, 18–35, 1959.

Author explains the method of "distributions" of L. Schwartz in a simplified form adapted to physical problems. The method has many advantages over classical analysis in that, for example, there are no restrictions on the differentiation of distributions or on differentiation term-by-term of a convergent series. The method is illustrated by application to the linearized problem of a nearly flat thin wing in supersonic flow; in particular to the symmetric wing at zero angle of attack and to an infinitely thin wing.

L. M. Milne-Thomson, USA

1331. Evans, W. T., On a simple relation of exact airfoil theory, *J. Aero/Space. Sci.* **26**, 7, 456–457 (Readers' Forum), July 1959.

Author calls attention to some interesting interpretative variations and related universal characteristics of the surface velocity distribution derived from exact incompressible potential flow theory for flow past two-dimensional airfoils.

M. G. Scherberg, USA

1332. Enselme, M., Two electrical analogies for the solution of wings (in French), *Rech. Aéro.* no. 64, 35–42, May–June 1958.

Paper presents two electrical analogies for the calculation of wings: one reproduces the velocity potential and the other the acceleration potential. The basic theoretical concepts and the boundary conditions which the two potentials have to fulfil are given and the manner in which they can practically be reproduced is shown. The analogy of the acceleration potential is treated in detail. A series of results obtained for a sweptback wing ($\varphi = 45°$, $\lambda = 4$) emphasizes the advantages of each analogy in various cases. M. I. Ionescu, Roumania

1333. Korst, H. H., Theoretical determination of the base pressure of separated flow (in German), *Öst. Ing.-Arch.* **11**, 3, 227–238, Nov. 1957.

A simplified flow model which was developed for studying separated flows apparently has proven useful—for near planar mixing regions—to illuminate the role of the parameters (in this case the Mach number and, in limiting cases, the Reynolds number. For thin boundary layers an asymptotic behavior is shown ahead of the separation position. Also a correlation is found between the lowest dead-water pressures and the asymptotic behavior. The limiting pressures can be computed without empirical information for those cases where the dead-water region is closed; this can be done for both laminar and turbulent mixing of streams. For open dead-water regions, one additional empirical quantity is necessary.

From author's summary by T. P. Torda, USA

1334. Ladson, C. L., Chordwise pressure distributions over several NACA 16-series airfoils at transonic Mach numbers up to 1.25, NASA Memo 6-1-59L, 285 pp., June 1959.

A two-dimensional wind-tunnel investigation of the pressure distributions over several NACA 16-series airfoils with thicknesses of 4, 6, 9, and 12% of the chord and design lift coefficients of 0, 0.2, and 0.5 has been conducted in the Langley airfoil test apparatus at transonic Mach numbers from 0.7 to 1.25. The tests ranged in Reynolds number from 2.4×10^6 to 2.8×10^6 and in angle of attack from $-10°$ to $12°$. Chordwise pressure distributions and schlieren flow photographs are presented without analysis. From author's summary

1335. Levy, L. L., Jr., Supersonic and moment-of-area rules combined for rapid zero-lift wave-drag calculations, NASA Memo 4-19-59A, 68 pp., June 1959.

Both the above rules evaluate wave drag as the sum of infinite series of squares of certain Fourier coefficients. The latter arise from harmonic analyses of the rate of growth of certain sectional areas of the configuration along its length. The supersonic area rule (s. a.) produces a rapidly convergent series, but each term is tedious to evaluate. The moment-of-area rule (m. a.) gives a more slowly convergent series, but the terms are evaluated readily, especially for Mach number unity.

This new method applies the latter technique to sheared configurations, obtaining results applicable to supersonic Mach numbers. Convergence is speeded by evaluating separately the drags of individual components of the configuration, and their interaction.

The new method gives as good or better accuracy than the s. a. rule for much less labor, and much better accuracy than the m. a. rule, admittedly at the cost of more work. The results differ by only a few per cent from those of slender-body and linearized theory.

It is clearly a useful method, especially where high-speed computers are not available. A. H. Armstrong, England

1336. Brown, C. E., and McLean, F. E., The problem of obtaining high lift-drag ratios at supersonic speeds, *J. Aero/Space Sci.* **26**, 5, 298–302, May 1959.

Subject problem is analyzed from point of view of conventional arrangements of wing and body and considering realistic possibilities. Conclusion is that the drag at zero lift does not offer much hope of reduction, but that the drag-rise factor ($\partial C_D / \partial C_L^2$) may. The most hopeful configuration is still the high-aspect-ratio sweptback wing cambered and twisted for optimum loading.

S. H. Maslen, USA

1337. Moul, M. T., and Brown, L. W., Effect of artificial pitch damping on the longitudinal and rolling stability of aircraft with negative static margins, NASA Memo 5-5-59L, 25 pp., June 1959.

Stability calculations and a simple closed-loop simulator were applied to a hypersonic glider configuration of 700 fps and 40,000 feet. Without a pitch damper the short-period mode was rapidly divergent for negative static margins and unsatisfactory in the simulator. With pitch damping the short-period response is stable and overdamped and easily controlled on the simulator. However, at negatives static margins, the phugoid mode must be checked for divergence and controllability problems. Rolling divergence in steady roll can be eliminated at all roll rates by an appropriate damper gain. H. P. Liepman, USA

1338. Hewes, D. E., Low-subsonic measurements of the static and oscillatory lateral stability derivatives of a sweptback-wing airplane configuration at angles of attack from −10° to 90°, NASA Memo 5-20-59L, 36 pp., June 1959.

The dynamic-force tests consisted of both linear and rotary-oscillation tests and were conducted at values of the reduced-frequency parameter k of 0.10, 0.15, and 0.20. The configuration was directionally unstable for all angles of attack above about 15° but maintained positive effective dihedral, control effectiveness, and damping-in-roll and yaw over most of the angle-of-attack range. From author's summary

1339. Krumhaar, H., Summary report of recent investigations on problems connected with gust loads on airplanes (in German), Mitt. Max Planck Inst. Stromungsforschung no. 21, 143 pp., 1958.

The generally employed single-gust method used for this type of investigation is also adopted by the author. Subsequently the analysis proceeds to the airplane in turbulent air, where the energy spectrum method is used. The results of both approaches are compared and the conclusion reached that they do agree qualitatively. It also becomes clear that the employment of the single-gust method leads to foggy, to say the least, explanations.

An excellent, deep study, with clear understanding and presentation of the mathematics involved, is enhanced by a fine, complete review of the available literature, 117 references being given. S. J. Zand, USA

Vibration and Wave Motion in Fluids

(See also Revs. 1173, 1253, 1271, 1297, 1305, 1439, 1464, 1468, 1469, 1470, 1494, 1565, 1576)

1340. Green, H. S., Propagation of disturbances at high frequencies in gases, liquids, and plasmas, *Physics of Fluids* **2,** 1, 31–39, Jan.–Feb. 1959.

An analytical method is developed to study propagation of small disturbances in fluids or gases with frequencies of the order of the lowest relaxation frequency or larger. The disturbance is defined as the remainder of a perturbation applied, at an earlier time, to the system in thermodynamic equilibrium. It is assumed that the resulting probability distribution in the system phase space is a slight modification of the equilibrium distribution, which modification can be described by a small displacement field in phase space. A condition for this displacement field is derived from Liouville's theorem, and is used to determine the behavior of the mean values for the coordinate and momentum displacements in the grand ensemble. Author restricts frequency of disturbance to values high enough to render the displacement of particles from their mean positions as almost independent of one another; the correlations between these displacements are subsequently neglected. Propagation of harmonic disturbances in a system of identical particles is studied for cases with real relaxation frequencies, resulting in a dispersion formula for frequencies of the same order as the relaxation frequency and wavelengths large compared with the mean particle distance. Approximate expression for propagation velocity is given for higher frequencies and wavelengths comparable to interparticle distance. Analysis is generalized to binary systems, and special consideration is given to Coulomb interactions. H. G. Loos, USA

1341. Ripp, M. G., Influence of the dynamic characteristics of a pipe conduit on the magnitude of water hammering in pumping installations (in Russian), *Izv. Dnepropetr. Gorn. In-ta* **27,** 90–96, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11130.

It is shown that Mostkov's recurrent formula [M. A. Mostkov and A. A. Pashkirov, "Calculations for water hammer," Gosenergoizdat, 1952] for the alteration in the number of revolutions in the pumping assembly during the occurrence of water hammering, appearing as the result of idling of the pumps motor, leads to the deduction of the independence in practice of this number from $\rho = j/2H$ and $c = \tau/T$ (j being the ordinate of the direct water hammer according to Zhukovskii, H the geodetic height of the force delivery, τ the impact phase in the delivery pipe-conduit, T the time of dying down of the pump assembly's racing) when $\rho < 1$, $c < 0.2$ within the limits of the first polyphase. Relying on this, author integrates the equation of the rotor of the pumping assembly without taking into account the water-hammer effect and obtains an approximate formula for the measurement of the number of rotations of the rotor in relation to time, only suitable for the given conditions. N. A. Kartvel'ishvili

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1342. Sukhomel, G. I., The length of the completed hydraulic jump in river beds of nonrectangular section (in Russian), *Izv. In-ta Gidrol. i Gidrotekh., Akad. Nauk USSR* **14,** 21, 3–6, 1956; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11141.

Author is of the opinion that the length of the completed hydraulic jump in a trapezoidal river bed is greater than in a rectangular bed of the same depth. An attempt is made by means of elementary arguments and calculations to clarify one of the reasons for this circumstance. Author asserts that M. D. Chertousov ["Special course in hydraulics," Gos. Energoizdat, 1949] and V. N. Evreinov ["Hydraulics," Izd-vo M-va Rechnogo Flota, SSSR, 1947] indicated that the length of jump in trapezoidal river beds is greater than in rectangular ones. This assertion is not true. Furthermore, Evreinov in the work cited actually expresses the opinion that "the length of the jump in a trapezoidal bed is somewhat smaller than in a rectangular one." (p. 601). O. F. Vasil'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1343. Eremenko, E., Two forms of hydraulic jump in a rectangular prismatic channel (in Russian), *Dop. Akad. Nauk URSR* no. 3, 261–264, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11142.

A description is given of two forms of hydraulic jump observable in a rectangular trapezoidal tank with a flow from below the grid. Near the grid, observation disclosed a complete jump, while further away from it there appeared a jump with lateral water diversions, and a crooked front to the jump. The reason for the formation of such a jump was looked for in the uneven distribution of velocities over the width of the flow before the jump, that is, in the action of the forces of friction on the side walls of the trough. T. N. Astaficheva

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1344. Gayed, Y. K., and Kamel, M. Y. M., Mechanics of secondary water-hammer waves, Instn. Mech. Engrs., Prepr., 11 pp., 1958.

While tests were being carried out on the motion which follows sudden closure of a valve at the beginning of a pipe, certain irregularities of the ensuing wave trains were noticed. Such irregularities were brought out all the more clearly because a sensitive electronic recorder was used. The special arrangement prevented the appearance of these irregularities, called secondary waves, during the first surge, which helped considerably the theoretical exposition. However, they were later superimposed on both the negative and positive surges. The reasons, which are not entirely different in both instances, are the main subject of discussion in this paper.

From authors' summary by P. Franke, Germany

1345. Gupta, A. S., A note on laminar motion due to the oscillation of a flat plate in a compressible fluid, Proc. 2nd Congr. Theor. Appl. Mech., New Delhi, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1956, 195–198.

The periodic laminar motion of a flat plate has been considered in a compressible flow with heat transfer. The boundary-layer equations are restricted to low Mach number and coefficient of viscosity proportional to temperature. It is found that the wall shear stress obeys the same law as in incompressible flow.

From author's summary

Fluid Machinery

(See Revs. 1265, 1277, 1281, 1382)

Flow and Flight Test Techniques and Measurements

(See also Revs. 1078, 1269, 1285, 1373, 1384, 1471, 1476, 1485)

Book—1346. Newell, F. B., Diaphragm characteristics, design and terminology, New York, American Society of Mechanical Engineers, 1958, v + 74 pp. $3.75 (Paperbound)

An effort has been made to describe diaphragm characteristics in a logical arrangement, and to show how they are affected by changes in material, dimensions and treatment. The manual is divided into two principal parts: The first defines a diaphragm and its performance characteristics, describes some methods of measuring and representing them and shows how they are related and used; the second part deals with ways in which diaphragms can be constructed and how various design details and treatments affect performance characteristics.

From author's summary

1347. Muntz, E. P., Pressure measurements in free molecule flow with a rotating arm apparatus, Univ. Toronto, Inst. Aerophys. TN 22, 38 pp., May 1958.

A rotating arm apparatus has been developed and used to measure the impact pressures of orifice and long-tube-type pressure probes in the free molecule flow regime.

Using this equipment, the validity for low-speed ratios of a theory for the pressure rise in long-tube free-molecule impact probes has been established.

An approximate short-tube theory is also presented, and its application to the geometrical conditions necessary to provide an effective true orifice is discussed.

From author's summary by R. J. Mindak, USA

1348. Martens, B. K., An electrical method for measuring the viscosity of liquids (in Russian), *Priborostroenie* no. 12, 25–26, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11365.

A description is given of a rotating viscometer, in which the inner cylinder is rigidly connected with a small frame located in the magnetic field. An impulse from an electric current is transmitted to the frame and the frame turns through a certain angle. The angle of rotation of the cylinder is inversely proportional to the viscosity of the liquid being observed and directly proportional to the amount of electricity passed through the small frame. The electrical arrangement of the apparatus guarantees the transmission to the frame of a strictly controlled quantity of electricity, consequently the angle of turn of the frame determines the liquid's viscosity.

A. I. Golubev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1349. Sibulkin, M., A total-temperature probe for high-temperature boundary-layer measurements, *J. Aero/Space Sci.* **26,** 7, 458–459 (Readers' Forum), July 1959.

This short note describes briefly a total-temperature probe for use in supersonic flow. It is small in one dimension and consists of a supersonic diffusor with variable exit.

Calibration results are given at a temperature level of 100 ± 20 F in a range of $M = 2.3$ to 5.0. A relation is derived that shows the dependence on the Reynolds number in the probe based on total temperature and on the density in the probe. References are given.

S. F. Erdmann, Holland

1350. Lefebvre, A. H., and Halls, G. A., Simulation of low combustion pressures by water injection, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 654–658.

Paper assesses the usefulness of this type of simulation. Results indicate that water injected in increasing amount with the fuel simulates an ambient pressure drop rather well. The method is comparatively cheap and quick and therefore judicious use should lower engine-development time and costs. Author presents a theoretical argument to support the effect and points out that this technique cannot be used on systems whose low-pressure performance is limited by a mixing time or droplet evaporation time.

R. A. Strehlow, USA

1351. Moulic, E. S., Afterglow investigations of shock detachment distances at low Reynolds numbers, WADC TR 57-643 (PB 151 449; ASTIA AD 155 795), 53 pp., July 1958.

An air afterglow flow visualization apparatus and free molecule probe were used to determine shock detachment distances for blunt bodies in the range $1.8 < M < 2.8$ and $100 < Re/\text{inch} < 1200$. Cylindrical models were used to develop the experimental techniques and reasonable agreement was shown between detachment distances measured by afterglow and free molecule probe techniques. Spherical model detachment distances were obtained by the afterglow technique and, when corrected for boundary-layer effects, showed satisfactory agreement with the predictions of Heybey, provided isentropic flow existed between the shock wave and the boundary layer. It was concluded that shock detachment distances in rarefied gas flows depend on Reynolds as well as Mach number.

From author's summary

1352. Wright, R. H., Ritchie, V. S., and Pearson, A. O., Characteristics of the Langley 8-foot transonic tunnel with slotted test section, NACA Rep. 1389, 87 pp., 1958.

The design and operational characteristics of the Langley 8-ft transonic tunnel are presented for Mach numbers up to approximately 1.14. The effects of slot shape and of a nonlifting model on the flow characteristics are illustrated and the surveys and calibration of the flow in the test section are described. The effects of boundary interference on pressure distributions and on body drag are shown to be negligible at subsonic Mach numbers and at the higher supersonic Mach numbers attained. Boundary-

interference effects at low supersonic Mach numbers are discussed and experimental data concerning model lengths for interference-free supersonic testing and locations of detached shock waves ahead of axially symmetric bodies are presented.

From authors' summary

1353. Huff, W. W., Jr., Application of dynamic testing procedures to stability and control flight test programs, AGARD Rep. 191, 18 pp., Apr. 1958.

Transient response testing is discussed from the points of view of aiding in the rapid extension of the flight envelope of a new model airplane, and introducing new test pilots to the subject of dynamic testing for stability and control characteristics.

The subject material is directed towards operational experiences rather than theoretical considerations. Specific attention is devoted to discussions of instrumentation and data-reduction prodecures, and test procedures used in investigating stability margins in roll maneuvers and high dynamic pressure flight conditions. Academic and flight programs used at the Test Pilot Training Division of the Naval Air Test Center, Patuxent River, Maryland, to introduce test pilot trainees to dynamic flight testing are discussed. From author's summary

1354. Hardy, J. D., and Clark, C. C., The development of dynamic flight simulation, *Aero/Space Engng.* **18,** 6, 48–52, June 1959.

Man's projects to go higher into space and at greater speeds have made the problem of acceleration an increasingly important one. This report deals with the incorporation of the acceleration forces into the flight simulator.

From authors' summary

Thermodynamics

(See also Revs. 1092, 1349, 1377, 1440)

1355. Carroll, C. W., Systematic approach to the calculation of thermodynamic transforms, *Amer. J. Phys.* **27,** 5, 302–306, May 1959.

Author discusses the basic mathematical tools necessary to transform some partial derivatives into other partial derivatives. Emphasis is put upon the desirability of being left with measurable quantities. D. Ter Haar, England

1356. Parker, J. G., Rotational and vibrational relaxation in diatomic gases, *Physics of Fluids* **2,** 4, 449–462, July–Aug. 1959.

Calculations of rotational and vibrational relaxation times for gases composed of homonuclear diatomic molecules have been carried out. A model consisting of an attractive component, which acts between geometrical centers of the molecules, and a repulsive component, which originates from two centers of force in each of the molecules, is used and the numbers of collisions to establish both rotational and vibrational equilibrium are calculated. Comparison with experiment for Cl_2, N_2 and O_2 indicates that the calculated rotational collision numbers are in good agreement with experimental results. The agreement between the calculated and experimental values of vibrational collision numbers for Cl_2 is good over a rather wide range of temperature, while for both N_2 and O_2 there is good agreement at high temperatures but not such good agreement at lower temperatures.

In an Appendix it is shown that the classical calculation of vibrational excitation by collision is in exact agreement with the quantum-mechanical calculation.

Z. Horak, Czechoslovakia

1357. Goldberger, M. L., On the second virial coefficient, *Physics of Fluids* **2,** 3, 252–255, May–June 1959.

Paper gives a new and straightforward method of calculating the second virial coefficient in quantum theory. For this, in an extended manner, ideas and methods of field theory are used. Particularly, a direct connection of the second virial coefficient with the determinant of the scattering matrix at fixed energy is shown. From the method several approximation techniques follow which seem to be superior to those known so far.

F. Engelmann, Germany

1358. Kac, M., On the partition function of a one-dimensional gas, *Physics of Fluids* **2,** 1, 8–12, Jan.-Feb. 1959.

A method is presented for calculating the grand-partition function of a one-dimensional gas with the potential $V(x) = +\infty$ for $0 \leq x < \delta$ and $V(x) = -\alpha \exp(-\gamma x)$ for $x \geq \delta$.

From author's summary by P. E. Kriezis, Greece

1359. Zwanzig, R. W., Contribution to the theory of Brownian motion, *Physics of Fluids* **2,** 1, 12–19, Jan.–Feb. 1959.

The probability density of a periodic system, having a period very short compared with time characteristic of its interaction with the environment, is considered in terms of action and phase variables. Its average over a time, long enough to include many interactions and very long compared with a period of the motion, is shown to be a solution of a Fokker-Planck equation. Explicit expressions for the friction coefficients are obtained. The properties of a harmonic oscillator with a special interaction are considered in detail. P. E. Kriezis, Greece

1360. Zumino, B., Formal solution of the equations of statistical equilibrium, *Physics of Fluids* **2,** 1, 20–22, Jan.–Feb. 1959.

A closed expression is given for the distribution functions in the classical theory of statistical equilibrium. This expression, when suitably expanded, permits one to obtain rather simply the general term in the virial expansion of the distribution functions and of the equation of state.

From author's summary by P. E. Kriezis, Greece

Book—1361. Thermodynamic and transport properties of gases, liquids and solids, ASME Heat Transfer Division, Purdue University, Lafayette, Ind., Feb. 1959; New York, McGraw-Hill Book Co., 1959, x + 472 pp. $12.50.

A collection of 42 papers presented at the 1959 Symposium on Thermal Properties. A few papers are of general interest, such as "Review of modern theory of the thermal conductivity of metals," by D. T. Schleef. The majority of papers are highly specialized and well documented. To anyone interested in such subjects as the viscosity of steam, the thermodynamic properties of boron compounds or the thermal conductivity of liquid ozone, this book will offer valuable tables, diagrams and references. Therefore it can be recommended to all extensive libraries.

Since it is not current practice to enter the various articles of such books as separate catalog items, there is unfortunately a certain danger that useful information will be stored without adequate means of locating this information.

R. Betchov, USA

Book—1362. Predvoditelev, A. S., Stupochenko, E. V., Samuilov, E. V., Stakhanov, I. P., Pleshanov, A. S., and Rozhdestvenskii, I. B., Tables of thermodynamic functions of air, London, Infosearch, Ltd., 1958, 301 pp. (Translated from Russian)

This volume forms one of a series of tables covering the range 1000° to 20,000°K. The following properties are each listed to four significant places: internal energy, enthalpy, entropy, specific heat at constant volume and at constant pressure, the ratio of specific heats, velocity of sound, density, molecular weight, and 13 molar fractions of the constituents of air.

From preface

1363. Chinitz, W., Eisen, C. L., and Gross, R. A., Aerothermodynamic and electrical properties of some gas mixtures to Mach 20, *ARS J.* **29**, 8, 573–579, Aug. 1959.

Authors apply orthodox chemical thermodynamics (including the Saha equation) and gas dynamics to the problem of computing the equilibrium properties and electrical conductivity behind shocks in air and detonations in mixtures of air with hydrogen or acetylene. The arduous calculations were performed on a digital computer. The electrical conductivity was assumed to be due to singly ionized nitric oxide or caesium, added in small amounts to increase the ionization markedly. The conductivities are based on cross-section data, using the formula appropriate to weakly ionized gas.

J. A. Shercliff, England

1364. Tippets, F. E., Relative thermal performance of carbon dioxide and helium in nuclear-power cycles, ASME Gas Turbine Power Conf., Cincinnati, Ohio, Mar. 1959. Pap. 59-GTP-14, 9 pp.

1365. Chao, G. T. Y., Isothermal compressibility of liquid oxygen and RP-1, *ARS J.* **29**, 3, 199–203, Mar. 1959.

The methods for computing the isothermal compressibility for RP-1 and liquid oxygen are presented. Liquid oxygen is a single substance, and RP-1 is a complex petroleum mixture, hence different methods of approach were used in each case. The accuracy of the calculated result is on the order of the experimentally derived result.

From author's summary

1366. Beams, J. W., Tensile strengths of liquid argon, helium, nitrogen, and oxygen, *Physics of Fluids* **2**, 1, 1–4, Jan.–Feb. 1959.

The tensile strengths of several liquids at low temperature were measured by a linear deceleration method. The values found were as follows (expressed in atmos): argon −12, nitrogen −10, oxygen −15, and helium −0.16. The values are somewhat lower than those calculated from the theory.

From author's summary

1367. Martinek, F., Nitrogen at high temperatures, AFOSR TN 59-264 (General Electric Co., Flight Propulsion Lab. Dept.; ASTIA AD 212 467), 52 pp., 1959.

The basic thermodynamic properties of pure nitrogen at high temperatures are presented. Internal energy, enthalpy, entropy, electron density, and electrical conductivity are given in engineering units for the temperature range from 5000 to 30,000 K, and pressures varying from 0.2 to 100 atm. The temperature and pressure dependency of dissociation and ionization is also shown. All calculations are based on statistical thermodynamics.

From author's summary

1368. Pnueli, D., Some thermodynamic properties of Freon-12, *Bull. Res. Council Israel*, **6C**, 3, 203–204 (Letters to the Editor), Aug. 1958.

1369. Rasskazov, D. S., Experimental research into the thermal capacity C_p of water vapour at pressures of 300–700 atm and temperatures of 280–700°C (in Russian), Avtoref. Diss. Kand. Tekhn. Nauk, Mosk. Energ. In-ta, Moscow, 1958; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7811.

1370. Herinckx, C., and Monfils, A., Electrical determination of the thermal parameters of semiconducting thermoelements, *Brit. J. Appl. Phys.* **10**, 5, 235–236 (Correspondence), May 1959.

Thermal conductivity, thermal capacity and electrical conductivity can be deduced from the observation of the time dependence of the electrical potential difference across a sample due to its own thermoelectric force. The mean temperature of the semiconductor must be measured. The Seebeck coefficient should be determined in a separate experiment.

W. L. Sibbitt, USA

1371. Rittner, E. S., On the theory of the Peltier heat pump, *J. Appl. Phys.* **30**, 5, 702–707, May 1959.

The figure of merit for a single-stage Peltier heat pump is optimized numerically allowing for the effect of Fermi statistics and taking the case of an extrinsic semi-conductor. It is found that for all cases of physical interest partial Fermi degeneracy prevails. The result is plotted against a dimensionless parameter characteristic of the material. (There is a misprint in the main formula of this part, Eq. [14].) Similar calculations have been made by Stavitskaya and Stilbans [*Zh. Tekn. Fiz., USSR* **28**, 3, p. 484, 1958] who plot their results against impurity concentration. The properties of a cascade operating at maximum coefficient of performance are discussed and attention is drawn to the problem of the heat leak in the absence of current flow.

G. N. Fowler, England

1372. Kohler, J. W. L., Physical aspects of the research on gas refrigerating machines (in Dutch), *Ingenieur* **70**, 49, w. 175-w. 178, Dec. 1958.

Many problems linked with the Stirling process prove to be of a rather fundamental nature. The reason is that, whereas normal refrigerating apparatus consists of rather isolated equipment connected in series, the Stirling process is performed in a single machine, which combines all functions; this gives rise to a number of difficult cross effects. Some examples of this are given; for instance the regenerator which is the most interesting, but difficult, element of the machine. The cycle is interesting as a fine illustration of a reversible cycle; the results of its study may be used on a broad front, i.e. also for the hot gas engine, the cold gas engine and the heat pump.

From author's summary

1373. Henshall, B. D., and Schultz, D. L., Some notes on the use of resistance thermometers for the measurement of heat transfer rates in shock tubes, Aero. Res. Counc. Lond. Curr. Pap. 408, 22 pp., 1959.

A brief description is given of the model calibration technique and the experimental data reduction employed at the N.P.L. in the determination of heat-transfer rates in a hypersonic shock tube. Estimates are made of the probable accuracy of such measurements, and specimen calculations and results are given.

From authors' summary

1374. Nielsen, K. E. C., Temperature measurements with thermistors in concrete, Swedish Cem. Conc. Res. Inst. Bull. no. 34, 44 pp., 1959.

This bulletin deals with the uses of thermistors for temperature measurements in the interior of concrete as well as for temperature measurements, automatic temperature recording, and automatic temperature control in laboratory equipment. The general properties of thermistors and the accuracy in measurements are studied in Chapter 2. Stability is the subject of a special investigation. The practical design of thermometers and accessory measuring equipment is described in Chapter 3. Four examples of application of thermistors at the Swedish Cement and Concrete Research Institute are given in Chapter 4.

The tests . . . to study the properties of thermistors, to develop thermometers for temperature measurements in the interior of concrete, and to devise laboratory equipment for automatic temperature recording and temperature control have shown that thermistors are very well adapted for these uses.

From author's summary by F. P. Bundy, USA

1375. Rao, M. R. K., Chittawadgi, B. S., and Murthy, N. S., Measurement of exhaust temperature in internal combustion engines, *J. Instn. Engrs., India*, **39**, 6, (Pt. II) 637–640, Feb. 1959.

Heat and Mass Transfer

(See also Revs. 1047, 1054, 1058, 1079, 1194, 1264, 1282, 1296, 1305, 1306, 1370, 1373, 1414, 1415, 1427, 1461, 1472, 1473, 1474, 1475)

1376. Biot, M. A., Further developments of new methods in heat-flow analysis, *J. Aero/Space Sci.* **26,** 6, 367–381, June 1959.

This paper is a continuation of the author's application of variational methods similar to those employed in analytical dynamics to thermal problems [AMR **10** (1957), Revs. 2291, 3838; AMR **11** (1958), Revs. 3738, 3739]. Each generalized coordinate is represented by a spatial temperature distribution and a vector field referred to as the "associated flow field." In the previous work dealing with one-dimensional problems a formal theory of the associated flow field was not needed because it could be computed from the temperature field by conservation of energy. However, a formal theory is needed for two- and three-dimensional problems.

A variational procedure is presented for computing the associated flow field from the temperature distribution, and some simple applications are presented. It is shown that the classical Green's function is a special case of the present method which affords a new approximate variational method for its evaluation.

W. Squire, USA

1377. Ioffe, A. V., and Ioffe, A. F., Measurement of the thermal conductivity of semiconductors in the vicinity of room temperatures, *Soviet Phys.-Tech. Phys.* **3,** 11, 2163–2168, June 1959. (Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **28,** 11, 2357–2363, Nov. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Authors discuss the sources of errors and the limitations on the application of their method for measuring thermal conductivity described in the *Zh. Tekh. Fiz., Akad. Nauk USSR* 1952, p. 2002. According to this nonstationary method the sample of investigated material is pressed between two cylindrical copper blocks with vertical axes, the lower one being suddenly immersed in ice water. The thermal conductivity of the sample is calculated from the measured temperatures of the lower and upper blocks and from the time interval between two consecutive readings of these temperatures. When the conditions described are adhered to, the method and apparatus provide a sufficiently accurate means for measuring thermal conduction in the range from 2.10^{-3} to 5.10^{-2} cal/deg/cm/sec in the vicinity of room temperature. At greater temperature differences between the lower and upper blocks errors in this method can increase so much that it becomes practically useless.

F. Krupka, Czechoslovakia

1378. Kaganov, M. A., A theoretical analysis of the method of measuring thermal conductivity of semiconductors proposed by A. V. Ioffe and A. F. Ioffe, *Soviet Phys.-Tech. Phys.* **3,** 11, 2169–2172, June 1959. (Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **28,** 11, 2364–2367, Nov. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

From the equation for the temperature distribution along the sample author deduces the time interval after beginning of the experiment during which the calculation of the thermal conductivity can proceed by the method. Further he states corrections which must be introduced into the basic formula to take into account the heat losses to the surrounding medium.

F. Krupka, Czechoslovakia

1379. Srivastava, B. N., and Srivastava, R. C., Thermal conductivity and Eucken correction for diatomic gases and binary gas mixtures, *J. Chem. Phys.* **30,** 5, 1200–1205, May 1959.

The thermal conductivity of pure oxygen, nitrogen, and hydrogen gases and of the binary gas mixtures O_2-A, N_2-A, and H_2-A at several concentrations has been measured by using a thick-wire conductivity cell at 38C. These data have been used to calculate the Eucken factor for the diatomic gases and the binary gas mixtures. The experimental value of the thermal conductivity and the Eucken factor have been compared with the theoretical values obtained on the Lennard-Jones (12 : 6) model. Hirschfelder's recent expression for the thermal conductivity of polyatomic gas mixtures has also been tested at some length. It is found that Hirschfelder's expression is substantially correct in its dependence on the individual conductivities.

From authors' summary by M. J. Goglia, USA

1380. Inman, R. M., Heat transfer for laminar flow in an annulus with porous walls, *J. Aero/Space Sci.* **26,** 8, 532–533 (Readers' Forum), Aug. 1959.

Temperature profiles and heat-transfer rates of established incompressible flow through an annulus channel with porous walls of constant temperatures are determined at different injection rates. Axial conduction and viscous dissipation are, as usual, neglected. Injecting fluid is tacitly assumed to have the same temperature as the porous wall.

L. S. Dzung, Switzerland

1381. Bjorklund, I. S., and Kays, W. M., Heat transfer concentric rotating cylinders, *ASME Trans.* **81**C (*J. Heat Transfer*), **3,** 175–186, Aug. 1959.

Experimental data are presented for heat transfer to air with four clearances between cylinders and with several combinations of outer-to-inner cylinder speed. Measurements indicate three flow regimes: First, at low peripheral velocities, laminar flow and heat transfer by conduction prevail; second, at speeds above a theoretically predictable value, vortex flow occurs and is the controlling mechanism; third, at higher speeds, a distorted vortex motion appears to be present. Empirical equations are developed that represent the correlated data, and a heat-and-mass-transfer-analogy solution for rotation only of inner cylinder predicts trends of data, but overestimates. Discussion of paper by others presents results from similar tests using water and oil as medium.

W. F. Davis, USA

1382. Sparrow, E. M., and Gregg, J. L., Heat transfer from a rotating disk to fluids of any Prandtl number, *ASME Trans.* **81**C (*J. Heat Transfer*), 3, 249–251 (Tech. Briefs), Aug. 1959.

Thermal boundary-layer equation for incompressible laminar flow over a rotating disk at constant surface temperature is reduced by means of von Karman's similarity variables and equations to an ordinary differential equation. This is solved by machine computation for selected Prandtl numbers over a wide range. Closed solutions are then found to the equation for extreme high and extreme low Prandtl numbers; computed curves are shown to approach extreme solutions as asymptotes. Thus results allow heat-transfer computations for any Prandtl number.

Reviewer believes work presented is also stimulating to further study of flow about disks and of machines using such disks.

W. Rice, USA

1383. Burbank, P. B., and Hodge, B. L., Distribution of heat transfer on a 10° cone at angles of attack from 0° to 15° for Mach numbers of 2.49 to 4.65 and a solution to the heat-transfer equation that permits complete machine calculations, NASA Memo 6-4-59L, 45 pp., June 1959.

Measured laminar heat-transfer coefficients at 0° angle of attack agree well with the Van Driest theory with Mangler transformation. At an angle of attack, the heat-transfer coefficients along the stagnation line are 1.9 to 4 times greater than at 0° angle, depending on Reynolds and Mach numbers and distance from nose tip. Boundary-layer transition and body vortices cause minimum heat-transfer coefficients to occur at the 90° and 120° meridian angles and increased aerodynamic heating along the 180° meridian, up to as much as along the stagnation line.

A method for complete automatic calculation of the heat-transfer

coefficient from the thermocouple readings was developed. A multichannel sequential analog converted four thermocouple outputs into digital form per second, transferring them to magnetic tape and punched cards. Full scale of 1000 counts represented 5 or 10 mv, with a resolution of 1/3° R for iron-constantan on 10 mv.

From authors' summary by C. F. Bonilla, USA

1384. Jones, J. J., Experimental investigation of the heat-transfer rate to a series of 20° cones of various surface finishes at a Mach number of 4.95, NASA Memo 6-10-59L, 26 pp., June 1959.

The tests were conducted in the Langley Gas Dynamics Branch in an axisymmetric Mach number 4.95 blowdown jet. The free-stream Reynolds numbers per foot varied from 20×10^6 to 100×10^6. The range of surface finish was from a very smooth polish to smooth machining with no polish (65 microinches rms). The results indicate that the turbulent heat-transfer rate for the highest roughness tested was only slightly greater than that for the smoothest surface. The laminar-sublayer thickness was calculated to be about half the roughness height for the roughest model at the highest value of unit Reynolds number tested.

From author's summary

1385. Wang, P.-h., On the convective heat transfer for turbulent flow of single-phase fluid through concentric annuli (in English), *Scientia Sinica* **8**, 1, 98–109, Jan. 1959.

As presented in a previous paper, preliminary experimental data on the heat-transfer coefficient at the inner wall for turbulent flow of water through concentric annuli with $d_2/d_1 = 1.84$ (d_1 and d_2 being the diameter of the inner and outer wall respectively) deviate from W. H. McAdams' and M. A. Mikheyev's recommended formulas, yet agree with E. S. Davis' equation. This paper gives a general survey on the knowledge of heat transfer in turbulent flow of single-phase fluid through concentric annuli. It is concluded that, although numerous investigations of forced convective heat transfer in concentric annuli were reported in literature, appreciable inconsistencies in the published data have made the known correlations for the heat-transfer coefficient at the inner wall uncertain. Further researches to clarify the subject from different aspects are suggested.

From author's summary

1386. Hartnett, J. P., Eckert, E. R. G., and Birkebak, R., Determination of convective heat transfer to nonisothermal surfaces including the effect of pressure gradient, Proc. Sixth Midwest. Conf. Fluid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 1959, 47–70.

A single design procedure is developed for the calculation of the local and total heat-transfer rates from nonisothermal surfaces with prescribed wall temperature distributions. The method is initially developed for laminar wedge-type flows and for turbulent flow with zero pressure gradient. An extension of the method to cover heat transfer from nonisothermal surfaces with arbitrary pressure gradient is proposed.

A solution is also given for the inverse problem of calculating the wall temperature distribution along surfaces with a prescribed heat and for turbulent flow with zero pressure gradient. Examples are presented to illustrate the proposed methods.

From authors' summary by H. Blok, Holland

1387. Thomann, H., Measurements of heat transfer and recovery temperature in regions of separated flow at a Mach number of 1.8 (in English), Flygtekn. Försöksanst. Medd. 82, 28 pp., Nov. 1958.

Heat transfer, recovery temperature, skin friction, and pressure distribution have been measured in regions of separated flow, produced by corners in the test wall. The Reynolds number of the turbulent boundary layer in the test section was 10^7, the Mach number 1.8.

The influence of separation on heat transfer and recovery temperature was remarkably low. The measurement of the skin friction showed that it is impossible to apply the Reynolds analogy without further knowledge of the flow field.

From author's summary

1388. Kosterin, S. I., and Magomedov, A. D., A study of viscous liquid motion in the presence of heat transfer in the region of large Prandtl numbers (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 10, 155–157, Oct. 1958.

Experimental results are presented of heat transfer and, in conjunction, pressure loss for both laminar and turbulent flow in pipes for $R = 50$ to 38,700. Glycerine while pumped through a closed circuit is heated electrically, then cooled by iced water in a jacketed straight test tube of 1-in. diam, 3-ft length. The experimental arrangement (which is part of the Krzhizhanowskii Thermo-Hydrodynamics Laboratory) and the painstaking technique are described in detail. Points of measurements are presented in graphs. The ratio of viscosity at the wall to viscosity of the fluid appears as an important parameter in the equations. Corresponding results by several Russian and foreign authors are reviewed. Good agreement is found to exist with the data of Sieder and Tate.

J. R. Weske, USA

1389. Pierce, R. D., Dwyer, O. E., and Martin, J. J., Heat transfer and fluid dynamics in mercury-water spray columns, *AIChE J.* **5**, 2, 257–262, June 1959.

Tests have shown that heat transfer from mercury sprays into a stream of rising water was lower than expected from data known for solid spheres. Agreement decreased greatly with lower *Re* numbers. The reason was an unexpected flow pattern of the water, bypassing the drops, and also a temperature distribution which did not allow making full use of a countercurrent heat exchange.

W. Gumz, Germany

1390. Farzetdinov, M. M., On the uniqueness of the solutions of the equation of weak convection in the steady state, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **22**, 2, 393–397, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Author considers heat transfer by natural convection in a volume of arbitrary shape which is surrounded by an infinite, solid medium. The temperature gradient at infinity is prescribed. The solution is expanded in terms of the Grashof number, and the uniqueness is proved.

N. Zuber, USA

1391. Cohen, N. B., A method for computing turbulent heat transfer in the presence of a streamwise pressure gradient for bodies in high-speed flow, NASA Memo 1-2-59L, 77 pp., Mar. 1959.

Proceeding from the friction and heat-transfer integral equations written for the axisymmetric compressible steady flow, author establishes a general relation between the heat transfer and the skin friction, which he calls the modified Reynolds analogy. For computations, the approximate Stewartson transformation is used, as well as numerous semi-empirical hypotheses, such as a linear relation between density and enthalpy, parabolic relations between velocity and enthalpy, "power-law" velocity profiles, an incompressible turbulent friction law, and negligible influence of the pressure and temperature gradient on the velocity profile. Two solutions, one exact and one approximate, are obtained applicable to arbitrary initial (transition) conditions and to fully developed turbulent flow respectively. These solutions agree satisfactorily with one another in the examined cases, i.e. flat plate, cone and cylinder in compressible flow. Comparison is made between author's computations and experimental heat-transfer results in case of a hemisphere at Mach numbers 5 and 2, of a flat-faced body at Mach number 5, and of a sphere-cone with various initial transition points.

Method is applicable to design purposes.

S. Savulescu, Roumania

1392. Rosner, D. E., Similitude treatment of hypersonic stagnation heat transfer, *ARS J.* **29,** 3, 215–216 (Tech. Notes), Mar. 1959.

Using the "similarity" between heat and mass transport, an expression for the convective heat-transfer rate at the nose of a blunt body is developed for dissociated but "chemically frozen" laminar flow with arbitrary surface catalytic activity. The result is shown to be identical in structure with recent solutions to the boundary-layer equations.

From author's summary by K. Stewartson, England

1393. Guy, W. T., Jr., Losom, L. B., and Crawford, G. W., Laplace transformation solution of simultaneous linear flow in two regions separated by a fixed boundary, Proc. Sixth Midwest. Conf. Fluid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 1959, 218–231.

The mathematical model represents a rectilinear section of semi-infinite extent and unit height of a continuous homogeneous, isotropic porous medium. The medium consists of two distinct regions of different fluid (heat) diffusivities separated by a fixed boundary. At this boundary, any resistance to flow is constant and non-capacitive. The inner region is treated as a uniform sink of unit length. The outer region does not contain a sink or a source. Eight different cases are considered.

From authors' summary by W. L. Sibbitt, USA

1394. Donskov, S. V., Heat transfer from tube bundles into a flowing granular material (sand) (in Russian), *Teploenergetika* no. 11, 76–81, Nov. 1958.

The equipment is essentially a vertical rectangular channel with a bundle of horizontal copper tubes. Two types of bundles were used: with in-line and staggered tubes. Each type was tested with several vertical and horizontal tube pitches.

Visual observations were made on two fractions of sand, 0.15 and 1.77 mm. The rate of flow was from 1.0 to 20.0 mm/sec. It was found that: (1) The flow around the tubes in a bundle occurs in the same way as around an isolated tube. (2) The mixing of the stream is greater for the staggered than for the in-line tube arrangement. The mixing mechanism in a sand flow is different from that in a fluid flow. (3) For the range of velocities employed a change of velocity did not cause a significant change in the character of flow. (4) Mixing increased with decrease in the horizontal pitch; a change of the vertical pitch was without effect.

Heat transfer was measured in bundles having six rows of three tubes each. The temperature of the tubes was maintained at 100C by built-in electric heaters. Thermocouples were used to measure the wall temperature to an accuracy of 0.12C. The temperature of the entering and leaving sand was measured as well as the temperature field below the lowest tube. Dry sand of three fractions (0.15, 0.93, 1.77 mm) was used. The flow rate ranged to 23 mm/sec. The measurement of the temperature field confirmed the visual observations. The results showed that: (1) In distinction to fluids the heat transfer from the first two rows of tubes (and especially from the first row) is greater than from the remaining rows. (2) Beginning with the third row the heat transfer becomes more or less stabilized (mean deviation ± 10%). (3) The heat transfer increases with decrease in tube pitch in both directions. (4) The heat transfer increases with decrease in the grain size of the material. (5) As with flow of fluids a greater heat transfer was found with the staggered arrangement. (6) With decrease of the Peclet number with the fraction 0.15 mm, the heat transfer increases in the last row, particularly with smaller tube pitches in both directions.

The results were correlated by a relation between the Nusselt and Peclet numbers in the form

$$Nu = 1/A\,(\lg Pe + B).$$

The coefficients A and B are dependent on the ratio of the diameter of the particles to the diameter of the tube and they can be determined from a table in the paper. The most detailed measurements were made for heat transfer from a staggered tube bundle where the tube pitch in the horizontal direction was 4, and in the vertical, 1 tube diameter. In this case, 96% of the experimental points lay within 10% of this relation.

G. Standart, Czechoslovakia

1395. Chechetkin, A. V., Heat exchange and the aerodynamics of a filtering flow (in Russian), *Trudi Mosk. Khim.-Tekhnol. In-ta Im. D. I. Mendeleeva* no. 24, 452–458, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11341.

The experimental data furnished by a number of authors on the resistance and heat exchange of a flow of gas through a filter layer are analyzed; the filter consisted of solid particles (coal, metallic balls, limestone, porous argillaceous clay, brick, etc.); the range of Reynolds numbers (constructed according to the equivalent diameter) was $1 < R < 7 \times 10^3$. On the basis of identical handling of the results of the various tests, empirical formulas are proposed to show the relation of the coefficient of resistance and the Nusselt number to the number R; three types of heat exchange emerge: the transient, the stationary and the conductive.

V. P. Mugalev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1396. Tabor, H., Radiation, convection and conduction coefficients in solar collectors, *Bull. Res. Counc. Israel,* **6C** *(Technology),* 3, 155–176, Aug. 1958.

Paper discusses at length the heat-transfer processes which contribute to the loss of heat from solar collectors. The most valuable feature is in showing how use of the more nearly correct value of 0.88 for glass hemispherical emissivity in place of 0.96 as originally assumed by Hottel [*ASME Trans.* **64,** 91–104, 1942] requires reassessment of the relative contributions of radiation and convection. Paper gives much quantitative data of value in computing the performance of solar absorbers, particularly with the development in recent years of radiation surfaces which absorb short-wave solar radiation, but reflect long-wave infrared radiation.

A. Whillier, South Africa

1397. Grigor'ev, B. A., Problems concerning the heating of an unbounded plate by an unsteady flow of radiative energy (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 1, 86–94, Jan. 1958.

The subject of the paper is the change in temperature of a plate of finite thickness which is exposed on one side to the radiation produced by a nuclear detonation. The time dependence of the incident radiation is taken from data which are published in the literature. The variation of temperature is obtained by solving the differential equation governing conduction of heat in one dimension. It is assumed that no energy is transmitted through that surface of the plate which is not exposed to radiation. Results are presented in the form of diagrams showing the change with time of the temperature at various depths of the plate. Particulars are given with respect to the highest temperature on the exposed surface.

The significance of the results is difficult to assess; in particular, the relevant solution of the differential equation is neither deduced nor verified, but taken from some reference.

R. Eisenschitz, England

1398. Wade, W. R., and Casey, F. W., Jr., Measurements of total hemispherical emissivity of several stably oxidized nickel-titanium carbide cemented hard metals from 600° F to 1,600° F, NASA Memo 5-13-59L, 31 pp., June 1959.

The measurements are presented for both as-received and polished test specimens together with a brief description of the equipment and procedures used. Results of investigations of the

surface condition of these materials as obtained by x-ray diffraction methods and metallurgical techniques are presented to indicate the type of surface on which these measurements were made.

From authors' summary

1399. Mathur, K. N., Khanna, M. L., Davey, T. N., and Suri, S. P., Domestic solar water heater, *J. Sci. Indust. Res., India* **18A,** 2, 51–58, Feb. 1959.

An arrangement for heating water with solar energy for supplying the domestic needs of a small family at Delhi, using easily available and inexpensive construction materials (galvanized iron sheets), has been described. The heat collector unit consists of a wooden box, insulated at the bottom, in which are formed the flow channels for water by one corrugated and one plane galvanized iron sheet. The upper side of the box is glazed with one or more layers of 1/8-in. thick window glass sheets to reduce heat losses, keeping a 2-in. gap between the glass sheets and the water flow channels.

As the length of the day is short and water requirements large during the winter, the heating unit is set up at an angle of 45° to the horizontal to make the best use of sunlight. Flow rates of water, through the collector unit, in the range 4–21 gal/hr have been used and a rate of 7–10 gal/hr has been found to be optimum under the experimental conditions employed. The efficiency of heat transfer on a clear day is about 70%, which is more than that for the usual types of heat collector units using copper pipes soldered to flat copper sheets. From authors' summary

1400. Bethe, H. A., and Adams, M. C., A theory for the ablation of glassy materials, *J. Aero/Space Sci.* **26,** 6, 321–328, 350, June 1959.

This paper constitutes another contribution in the growing literature on approximate analytical treatment of boundary-layer equations connected with ablation of various materials. For sake of simplicity the condition is analyzed for a steady-state ablation of an axisymmetric body at the stagnation point. Suggestion is included on how to extend the analytical treatment to other points of the contour. The treatment is eclectic in the sense that boundary conditions on the gas-liquid interface are assumed in the form of analytical expressions obtained from another paper [Fay, J. A., Riddell, F. R., and Kemp, N. H.: "Stagnation point heat transfer in dissociated air flow," *Jet Propulsion* **27,** no. 6, June 1957; AMR **10** (1957), Rev. 4181] and the temperature dependence of glass viscosity is represented by an empirical formula having a large exponent and obtained from industrial bulletins. This type of exponential dependence allows rather simple integration of boundary-layer equations and determination of the temperature distribution within the liquid layer. This, in turn, yields such practical parameters as ablation velocity and ablation energy.

This paper treats separately the case of ablation without evaporation and that with partial evaporation of ablating liquid, the latter introducing strong interaction between the liquid and gaseous boundary layers. Numerical examples are calculated and plotted for Pyrex glass, showing the effective energy absorbed at the stagnation point for various altitudes and velocities of flight.

Paper is obviously aimed at obtaining important simple workable relations rather than solving a mathematical problem in an elegant and general form. This reviewer feels that this purpose has been largely accomplished. On the other hand, authors do not seem to emphasize sufficiently the limitations of their method: for example, the limitations of the analyzed boundary-layer model caused by the instability of Taylor or Rayleigh type, or conditions when the axisymmetric flow pattern is distorted by a considerable amount in a yawed flow or for irregular body shape. Authors feel that their treatment could be easily extended, in principle, to the nonstationary case. This reviewer feels, however, that certain forms of nonstationary flow may introduce strong discontinuities and irregularities in the gaseous boundary layer which could hardly be expressed in analytical form and then integrated into the authors' proposed method of treating analytically the boundary conditions in the liquid layer. This might necessitate numerical solutions which would be similar to other proposed numerical methods of treating ablation problems. B. Zarwyn, USA

1401. Harbeck, G. E., Jr., and Koberg, G. E., A method of evaluating the effect of a monomolecular film in suppressing reservoir evaporation, *J. Geophys. Res.* **64,** 1, 89–93, Jan. 1959.

Evaporation from a water surface may be reduced by the application of a monomolecular film. Because of possible seasonal variations in evaporation-pan coefficients, computed savings in evaporation may be unreliable if based upon evaporation-pan records. A more reliable measure of the evaporation reduction is obtained by the solution of equations based upon energy budget and heat and mass transfer theory. The rise in water-surface temperature caused by application of the film can be computed.

From authors' summary

1402. Zubkov, V. I., On the evaporation of solid globules in a gas flow, *Soviet Phys.-Doklady* **3,** 6, 1121–1123, June 1959. (Translation of *Doklady Akad. Nauk SSSR (N.S.)* **123,** 5, 803–805, Dec. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Naphthalene and camphor spheres were evaporated in an air stream, and by photographically measuring the spheres at one to two-minute intervals the rate of evaporation at various sections was determined. Claims are made for measurements over wide range of conditions, but this note contains no quantitative information. A. C. Mueller, USA

1403. Staprans, V. Ya., Capillary condensation (in Russian), *Trudi Labor. Gidrogeol. Problem Akad. Nauk SSSR* **12,** 89–92, 1955; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11264.

Results are given of observations on the changes in humidity of porous materials in an atmosphere saturated with water vapor. A slow diminution of humidity is reported. The hypotheses is advanced of the predominant influence of evaporation from a convex meniscus (by comparison with condensation on a concave surface).

A. A. Gukhman

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1404. Fuks, N. A., On the theory of evaporation of fine droplets (in Russian), *Zh. Tekh. Fiz.* **28,** 1, 159–162, 1958; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11265.

A formula is derived for the calculation of the velocity of evaporation in a gaseous type of medium of drops of small magnitude, not far removed in size from the mean of free-running molecules of steam. This deduction is based on the assumption that in the layer next the wall, shorter in length than the free run, the exchange of molecules takes place as in a vacuum, while outside this layer the equation for diffusion holds good. The expression obtained was compared with the experimental material of other investigators and showed good correspondence of the experimental and calculated data, and the applicability of the expression for calculating the evaporation of drops of large dimensions.

G. A. Varshavskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1405. Kuznetsov, S. P., Investigation of the nonstationary fields of temperature and humidity in an unbounded plate with no humidity evaporation (in Russian), *Izv. Tomskogo Politekh. In-ta* **89,** 8–18, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11270.

The nonstationary problem is examined concerning the heat conductivity and moisture conductivity for an unbounded plate. The thermal-physical constants are accepted as constant. The evaporation of the moisture is disregarded. The solution of the common

system of differential equations for the heat conductivity and the moisture conductivity is carried out with boundary conditions of the first order by the method of Laplace conversions. For small and large Fourier numbers different forms of the solution are obtained.

K. K. Vasilevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1406. Metzner, A. B., and Friend, W. L., Theoretical analogies between heat, mass and momentum transfer and modifications for fluids of high Prandtl or Schmidt numbers, *Canad. J. Chem. Engng.* **36**, 6, 235–240, Dec. 1958.

The presently available analogies for turbulent flow inside smooth round tubes are reviewed in detail; an empirical coefficient in the most promising equation is evaluated experimentally using the first heat-transfer data of high accuracy obtained in the region of Prandtl numbers above 100. The final correlation is based on both heat- and mass-transfer data, and covers Prandtl (or Schmidt) numbers from 0.46 to 3000. Up to Prandtl or Schmidt numbers of 600 the results are correlated with a standard deviation of 9.4%.

From authors' summary by E. V. Somers, USA

Combustion

(See also Revs. 1309, 1363, 1392, 1447, 1448, 1499, 1500, 1501, 1503, 1516, 1519)

1407. Khitrin, L. N., On some consequences of the thermal theory of ignition in a fast flow, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 470–474.

Author applies a previously reported method of the prediction of ignition limits to combustible fluids in motion. Emphasis is placed upon the effect of variations in local thermal transport from a heated body upon the ignition process. No consideration is given to mechanisms, flame formation or the kinetics of the reaction occurring in the induction period. The effect of variation of local heat transfer upon the ignition of the flowing gas past a heated flat plate and a heated cylinder is considered in some detail. From the relationships derived, the ignition limits for mixtures of combustible gases are established and found to be in agreement with the experimental data from mixtures of hydrogen and carbon monoxide burned in oxygen. Author focuses his attention upon the development of a simple analytical solution which will yield at least semi-quantitatively the effects of the heated body used to ignite a flowing gas. No comparison is made on the predicted behavior with the experiment.

B. H. Sage, USA

1408. Marsel, J., and Kramer, L., Spontaneous ignition properties of metal alkyls, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 906–912.

1409. Rose, H. E., and Priede, T., An investigation of the characteristics of spark discharges as employed in ignition experiments, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 454–463.

1410. van Krevelen, D. W., and Chermin, H. A. G., Generalized flame stability diagram for the prediction of interchangability of gases, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 358–368.

Authors develop mathematical expressions for defining the stability curves of arbitrary gas mixtures. The flame stability diagrams for any flame system are characterized by boundary velocity gradient quantities related to the peak of the flashback curve, the half-peak width of the flashback curve, and the velocity gradient at blow-off (relative to the peak of the flashback curve). Generalized diagrams are developed for reduced (dimensionless) boundary velocity gradient and reduced gas concentration for several binary-fuel gas mixtures.

A. Levy, USA

1411. Clarke, A. E., Harrison, A. J., and Odgers, J., Combustion stability in a spherical combustor, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 664–673.

Combustion in a flowing system was experimentally investigated. The conditions were similar to those that might exist in a turbojet combustor, i.e. where there is high output combustion as a result of intense recirculation of the hot products of combustion with the original unburned fuel-air entering the system. The spherical combustors (3/8-in. to 1-in. diameter injectors within 3-in. diameter spheres) were modelled after those of Longwell and Weiss [*Indust. Engng. Chem.* **47**, p. 1634, 1955]. Both pressure drop and mixing effect were observed when blow-out occurred in the spherical combustor. The effect of the following variables was investigated: air-flow rate, fuel-flow rate, combustor pressure, equivalence ratio, inlet burning volume, and injector feed-hole diameter.

Authors concluded that: (1) The maximum volumetric heat-release rates for propane and isooctane-air mixtures at the same conditions of inlet temperature were similar. Propane decomposed approximately twice as fast as isooctane. (2) A reaction order of 1.8 was assigned to the combustion of propane-air mixtures, agreeing with the order suggested by Longwell for isooctane combustion. (3) There was an inprovement in the scatter of results when the parameter $\left(\frac{\Delta P}{P}\right)^{1/4}$ was introduced into the correlation as a mixing term, where ΔP = (Injector total pressure − combustion space pressure), and P = Injector total pressure.

Reviewer brings to the readers attention the discussion of this paper, especially with respect to conclusion (3), appearing in the title source, p. 737. The acceptance of the parameter $\frac{\Delta P}{P}^{1/4}$ into the original correlation of Longwell and Weiss, $(N/P^{1.8}V)$ or $N/P^{1.8}V)/(\Delta P/P)^{1/2}$, where N = air mass flow and V = combustor volume, is questioned for its applicability to reactors of all sizes and to all chamber pressures. The purported limitation of combustion rates by reaction kinetics is discussed. It is suggested that an appreciable mixing time may exist in the spherical combustor, possibly because of nonhomogeneity in the reactor due to flow and combustion patterns.

J. M. Singer, USA

1412. Wong, E. L., Flame stability effect of gases ejected into a stream from a bluff-body flameholder, NASA TN D-128, 26 pp., Aug. 1959.

The effect of gas ejection from a bluff-body flame holder on the stability of propane-air flames was studied using the following additives: hydrogen, air, and a premixed hydrogen-air mixture. Ejection of premixed hydrogen and air substantially increases blowoff velocities in both rich and lean propane-air mixtures. The effect of these additives was attributed to the changed gas composition in a critical region adjacent to the flame holder. A method of estimating the dimensions and the effective gas composition of this critical region is presented, which can be used to predict approximately the effect of additives on the basis of fundamental combustion parameters.

From author's summary

1413. Butze, H. F., and Metzler, A. J., Exploratory investigation of aerodynamic flameholders for afterburner application, NASA Memo 4-9-59E, 7 pp., May 1959.

The flame-holding capabilities of a number of aerodynamic jets and of combinations of these jets with a V-gutter flame holder were investigated at severe afterburner operating conditions. At an inlet-air velocity of 600 fps, no aerodynamic flame holder alone was able to maintain stable combustion at flow rates and injection pressures that would be available from compressor-bleed air. With various combinations of a V-gutter flame holder and aerodynamic jets, stable combustion was achieved at the velocity given; however, no improvement in combustion efficiency was obtained.

From authors' summary

1414. Fetting, F., Choudhury, A. P. R., and Wilhelm, R. H., Turbulent flame blow-off stability: Effect of auxillary gas addition into separation zone, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 621–632.

This is a detailed examination of the flame stabilizing process and the blow-off data obtained on a 5-mm cylinder, using primary mixtures of propane and air, with additives of hydrogen, oxygen, methane, carbon monoxide, nitrogen, and helium at the upstream and downstream stagnation points, and at the sides. The critical zone for flame holding is identified as lying at the end of the luminous zone between the free extension of the boundary-layer flow off the rod and the recirculation zone; the critical zone is in the triangularly shaped fine scale turbulence region, between the free layer and the surface of the rod, and beyond the end of the luminous zone close to the rod surface. On the basis of maximum chemically possible reaction rate per unit volume, reviewer feels that it makes more sense to assign the combustion to the luminous zone and the stability of the flame to the upstream end than to treat the wake volume as a controlling homogeneous reactor.

A. A. Putnam, USA

1415. Bovina, T. A., Studies of exchange between re-circulation zone behind the flame-holder and outer flow, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 692–696.

Optical measurement of rate of reduction of concentration of dust in cold flow recirculation zone, and of sodium light intensity in combustion flow recirculation zone, was used to evaluate diffusion coefficient D in recirculation zone. For cold flow, $D = D_t + 0.004\,dV$, where D_t is the upstream diffusion coefficient, d obstacle diameter, and V the stream velocity. D_t, d, and V were all varied in study. For combustion, d/V, D_t, and mixture ratio were varied. No effect of mixture ratio was found. The effect of the other two variations was as before, but no full equation is given. For normal stream turbulence, i.e. no close upstream grid, the residence time with combustion was 3.7 times that without combustion. Thus, neglecting change in size of flameholding region, D would be decreased by a similar factor. Information of this type should aid in the quantitative evaluation of flameholding theories based on the postulate that there is a homogeneous reaction in the recirculation zone, and that this reaction is critical to the flameholding process.

A. A. Putnam, USA

1416. Matton, G., Influence of restriction of a stream by flame holders on limits of extinction (in French), *Rech. Aéro.* no. 63, 3–11, Mar./Apr. 1958.

The stabilization of flames in high-velocity jet streams by the use of flame holders is of immense practical significance. Author has extended his study of this problem and has related flame extinction limits to the velocity V' of the jet stream in the wake of an object, the height d' of the emergent stream, and the fuel-air ratio of the incident stream. From pressure measurements at the base of the holder, V' may be calculated as a function of the mean stream velocity and pressure ahead of the holder. The height of the wake stream, d', can be related to the cross-sectional height of the obstacle.

In his present paper the author considers the effect of blockage of the jet stream by a holder on the quantities V' and d' and hence on flame extinction. He gives a theoretical treatment for cylindrical and toroidal objects which agrees well with practice and enables quantitative corrections, for blockage effects, of aerodynamic properties of objects determined in essentially unrestricted streams.

M. F. Hoare, England

1417. Lewis Laboratory Staff, A summary of preliminary investigations into the characteristics of combustion screech in ducted burners, NACA Rep. 1384, 18 pp., 1958.

Operation of afterburners and ramjet combustors at progressively higher fuel-air ratios has increased the occurrence and intensity of screech. Because of the destructive characteristics of screech, considerable effort has been expended in an attempt to understand and control this phenomenon. The present report summarizes NACA work on screech prior to November 1953. To determine the effects of design and operational variables on screech frequency and intensity, studies have been conducted in combustors ranging from 6 to 37 inches in diameter. Attempts to eliminate screech by reducing the driving potential of the gas stream were generally unsuccessful, but the use of an acoustic damper completely eliminated screech in all burner configurations in which it was used.

From authors' summary

1418. Barbor, R. P., Larkin, J. D., Von Rosenberg, H. E., and Shipman, C. W., The study of flow and reaction rates in turbulent flames, *AIChE J.* **5,** 1, 37–46, Mar. 1959.

Authors present results of propane-air combustion experiments utilizing two ramjet-type combustion chambers, one operating at atmospheric pressure and the other at 0.2 atmospheres. Static pressure, total pressure, and gas sampling measurements were made at several points in the turbulent two-dimensional flow field downstream from the bluff body flame holder. Authors present curves providing a detailed mapping of the flow field, composition, velocity, eddy viscosity, and reaction rate, which were computed as follows:

Assuming that with the sampling velocity equal to the flow velocity the sample composition would equal the true local (time-average) composition, local compositions of CO_2, CO, O_2 and unburned material were determined by an Orsat analysis. The local density was computed from the composition by assuming flame zone properties that are not inconsistent with the wrinkled laminar flame model. The local velocity was determined from the static and total pressures by neglecting the difference between the time-average velocity and the square root of the time average of the square of the velocity. The streamline directions were calculated from the velocities and densities by computing the mass flow rate across transverse areas. It was then possible, by numerical differentiation, to evaluate the convective mass flux term in the turbulent diffusion equation, and to solve for an effective chemical reaction rate, which includes the turbulent diffusion rate and the rate of production of burned gas. By similar numerical techniques, a turbulent momentum equation was solved for the eddy viscosity, and the turbulent mass diffusivity was computed by assuming a turbulent Schmidt number of unity. It was then possible to evaluate the turbulent diffusive flux in order to obtain the true chemical reaction rate.

While the procedure is very laborious, it may possibly be applied to practical combustors, and it has the advantage of showing many important details that would escape detection by less complete analysis. For example, evidence was obtained that the turbulent Schmidt number exceeds unity in regions where strong turbulence is generated by the walls or the bluff body; the local concentrations of reactants and products were found to be determined by the local oxygen concentration; and the sampling velocity exhibited a great effect upon the measured composition in inhomogeneous regions.

F. A. Williams, USA

1419. Bunt, E. A., Mass analysis of flames and flue gases, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 325–331.

Potentialities of mass spectrographic analysis of gases withdrawn from flames burning at atmospheric pressure were investigated. Conventional instrument with a simplified Nier-type ion source was used. Gas was collected with hypodermic needle flame probe and expanded through viscous flow leak and molecular flow leak. Fairly cool flames (e.g. coal-gas/air) could be scanned continuously; hotter flames (e.g. oxyacetylene) soon destroyed the probe, which was used simply to withdraw samples.

Six zones of a coal-gas/air flame were studied in some detail. Luminous and nonluminous parts differed significantly, but there was not a large difference between the inner, bright blue zone and the outer, light blue zone. Both CO and CH_4 appeared to react in the inner zone. Work also covered combustion products: auto exhaust, flue gases, human breath. Exhaust from idling auto did not contain acetylene as reported by others.

"Live" and "dead" samples gave similar results, showing that the "live" sampling was not fast enough to capture short-lived intermediates. However, oxygen and nitrogen ions formed in the flames persisted long enough to record. There were various limitations: absolute peak heights depended on emission current; absorption and elutriation interfered with stability; water vapor reduced life of filament; important peaks (e.g. N_2, CO) coincided. Work showed an apparent low sensitivity of mass spectrometer to combustion products, but direct sampling from flame gave more information. Unexpectedly, free carbon was detectable.

R. A. W. Hill, Scotland

1420. Tesner, P. A., Formation of dispersed carbon by thermal decomposition of hydrocarbons, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 546–553.

1421. Van der Held, E. F. M., Formation and gasification of carbon in an atmosphere in combustion products, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 554–558.

1422. Singer, J. M., and Grumer, J., Carbon formation in very rich hydrocarbon-air flames, Part I: Studies of chemical content, temperature, ionization and particulate matter, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 559–569.

1423. Breisacher, P., Dembrow, D., and Berl, W. G., Flame front structures of lean diborane-air and diborane-hydrocarbon-air mixtures, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 894–902.

1424. Gerstein, M., A study of alkylsilane flames, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 903–905.

1425. Dickey, F. P., and Hoffman, J. M., Application of phase-discrimination method of detection to the study of the spectrum of the OH radical in an oxyacetylene flame, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 938–941.

1426. Lewis, J. D., and Merrington, A. C., Combustion of n-heptane spray in decomposition products of concentrated hydrogen peroxide, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 953–957.

Paper describes apparatus for laboratory examination of the injection and burning characteristics of fuel sprays necessary for the combustion process in liquid propellent rocket engines. A simplification has been made by studying a single fuel spray burning in a gaseous oxidizing atmosphere. Cylindrical and rectangular combustion chambers, with provision for inserting a gas sampling probe at various downstream positions and optical examination, and the novel probe based on a water-cooled double sonic orifice system are described. Apparatus allows the collection of a series of small samples without condensation or fractionation for later analysis. Gas composition is given for a traverse across the chamber at one position and on the axis at two positions. High-speed photographs of flame pattern and spark shadowgraphs of the fan spray for the rectangular chamber are shown. Few detailed results are given but a technique is well described which will be of interest to researchers in the field of combustion.

A. F. W. Langford, Australia

1427. Spalding, D. B., Theory of rate of spread of confined turbulent pre-mixed flames, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 595–603.

Spreading of turbulent pre-mixed flames from central baffles in two-dimensional flows at high stream velocities is predicted by assuming that the flame entrains fluid from its surroundings just as though it were a turbulent jet and that the entrainment rate controls the burning rate. The entrainment rate is obtained by correlating experimental data on mixing of parallel fluid streams. Quantitative agreement with experimental results is fairly good.

T. Y. Toong, USA

1428. Grover, J. H., Fales, E. N., and Scurlock, A. C., Turbulent flame studies in a two-dimensional open burner, *ARS J.* **29,** 4, 275–283, Apr. 1959.

A two-dimensional open burner has been developed for studying turbulent flames. Stoichiometric natural gas-air flames with inlet flow velocities of 15, 20, 30 and 40 fps were investigated. Densitometer traverses of time exposures were used to locate the position of the mean flame front and its root-mean-square displacement. Flash tube exposures of the flame with one-micron magnesium oxide particles in the flow were taken to determine the flow lines into and through the flame front. The large reduction of brightness that occurred when the flow passed through the flame front, due to the reduction of particle concentration, shows clearly the outline of the instantaneously wrinkled flame front and the islands of unburned gas often present in the burned gas. From the intercepts of the flow lines and the mean flame front, the local turbulent flame velocity along the flame front was calculated. The turbulent flame velocity increased rapidly with distance above the burner rim. The flame velocity increase can be entirely accounted for by flame wrinkling. Both this result and the appearance of the flash tube photographs, showing the instantaneous flame front, support the wrinkled flame concept of turbulent flame propagation.

From authors' summary

1429. Bollinger, L. E., and Edse, R., Investigation of the premixed jet fuel–red fuming nitric acid rocket propellant system, WADC TR 57-407 (PB 131 568; ASTIA AD 142 108), 25 pp., Oct. 1957.

An experimental investigation of premixing jet fuel and red fuming nitric acid was conducted on a nominal 25-pound thrust scale at a design chamber pressure of 300 psia. In 30 experiments it was not possible to reach desired operating conditions because of the poor combustion characteristics of the propellant in the engine configurations employed. The fuel tended to quench the flame completely or to make the flame move through the exhaust nozzle and burn outside. No particular problems were encountered with premixing the fuel and oxidizer. The relatively

few flash-backs that did occur were induced probably by the severe oscillations caused by combustion instability. In no instance did the flame travel back through the four-foot line from the injector to the propellant mixing vessel during explosions and flash-back.

From authors' summary

1430. Uberoi, M. S., Flow field of a flame in a channel, *Physics of Fluids* **2**, 1, 72-78, Jan.-Feb. 1959.

A stationary flame is stabilized in a two-dimensional channel, and the entire flow field is investigated by the suspended particles method. The measurement of the flow field of a flame shows that except near the walls the flame speed is constant, and the tangential velocity is continuous across the flame. Considering the flame front as a surface of discontinuity of density, the possibility of obtaining an analytic flow field on the basis of constant flame speed is examined under the assumption of inviscid and incompressible flow. It appears that no solution exists unless the channel walls in the region of burned gases are displaced inward. This investigation, together with author's previous work on the flow field of a Bunsen flame, leads to the following conclusion on the structure and stability of laminar flame: that convex flames are possible and concave ones impossible. This prediction is in agreement with the observation of cellular flames.

S. Kumagai, Japan

1431. Mayer, E., Vaporization rate limited combustion in bipropellant rocket chambers, *ARS J.* **29**, 7, 505-513, July 1959.

Research here indicates that the factors time, temperature, turbulence pressure *and* emissivity govern the rate of vaporization of droplets in suspension. Black oils which require roughly twice the temperature level for vaporization which would be required for distillate oils vaporize with equal rapidity because, being black, they absorb heat by radiation much more rapidly than the distillate oils.

The data of Fig. [1] of the paper could well be reviewed with black or red dyestuff as an additive to the fuels.

We find burning and/or vaporization rates at a temperature are in direct proportion to the absolute pressure. The data are taken on the basis of 300 lb psia. It is presumed this pressure is critical in the use of propellants; however, research may show that higher absolute pressures and higher burning vaporization rates may be of significant value.

R. D. Reed, USA

1432. Miller, R. O., and Brown, D. D., Effect of ozone addition on combustion efficiency of hydrogen–liquid-oxygen propellant in small rockets, NASA Memo 5-26-59E, 18 pp., June 1959.

An experimental study shows that 2% by weight ozone in oxygen has little effect on overall reactivity for a range of oxidant-fuel weight ratios from 1 to 6. This conclusion is based on characteristic-velocity measurements in 200-pound-thrust chambers at 300 pounds per square inch absolute with low-efficiency injectors. The presence of 9% ozone in oxygen also did not affect performance in an efficient chamber. Explosions were encountered when equipment or procedure permitted ozone to concentrate locally. These experiments indicate that even small amounts of ozone in oxygen can cause operational problems.

From authors' summary

1433. Zabetakis, M. G., Lambiris, S., and Scott, G. S., Flame temperatures of limit mixtures, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28-Sept. 3, 1958; New York, Academic Press, 1959, 484-487.

Earlier work on limit mixtures by G. W. Jones et alia has been extended to cover the effects of initial temperature and pressure and of diluents.

Upward propagation in a 2-in. ID tube was used, the vessel being glass and 48 in. long for all but the pressure work which was conducted in a steel tube 12 in. long. Ignition was by HT spark for low pressure and fused platinum wire, sometimes augmented with gun cotten, for high pressure.

In temperature range 27-200 C the calculated adiabatic limit flame temperature T_f only varied ±20 C for normal paraffins *n*-hexane to *n*-decane. There was no evidence of systematic change of T_f with increasing molecular weight as found by Egerton and Powling [*Proc. Roy. Soc. Lond.* **193**, p. 190, 1948].

Modified Burgess and Wheeler law can be written

$$LC + H = k$$

where L is lower limit, C is heat of combustion, H is heat added in raising temperature and k depends on combustible and direction of propagation.

With increasing pressure, T_f falls, particularly for the upper limit. For closed tube limits T_f is best calculated on basis of constant pressure rather than constant volume.

Diluents, replacing N_2, have little effect on T_f with exception of helium. Irrespective of diluents, minimum oxygen requirements appear to occur above 500 psig.

Reviewer wonders whether the effect of helium is entirely one of increased thermal conduction, as claimed, or whether ineffectiveness as a chaperon results in higher T_f requirement.

D. B. Leason, England

1434. Olson, W. T., and Setze, P. C., Some combustion problems of high-energy fuels for aircraft, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28-Sept. 3, 1958; New York, Academic Press, 1959, 883-893.

1435. Harrison, P. L., The combustion of titanium and zirconium, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28-Sept. 3, 1958; New York, Academic Press, 1959, 913-918.

Book—1436. Corrosion and deposits in boilers and gas turbines, New York, American Society of Mechanical Engineers, 1959, vii + 198 pp. $6. (Paperbound).

The book sets out to review all available information on this continuingly important project and it must be immediately stated that great credit is due to the eight members of the staff of the Battelle Memorial Institute for the careful way they have collected and ordered their material.

The subject matter is divided into seven sections, each taking one chapter. Each chapter is complete with its own summary and references—an excellent aid to quick assimilation. Chapter 1, by Nelson, is divided into two parts, one dealing with the mineral constituents of coal and the other with heavy fuel oil. The behavior of this mineral matter in combustion is described, particular attention being paid, of course, to sulphur and, in relation to British experience with solid fuels, to chloride salts. The mechanism of the release of alkali material, phosphorus and silica on heating solid fuels is outlined, while consideration is given, with liquid fuels, to alkali, vanadium and nickel compounds.

Chapter 2, by Krause, is concerned with the mechanism of formation of sulphur oxides—especially SO_3—in flue gases. It is concluded that the formation of the trioxide by means other than catalytic oxidation is negligible, a statement that will be disputed by those workers who are convinced that appreciable amounts of SO_3 are formed in most combustion processes. There would appear plenty of evidence that gases leaving the combustion zone in many boilers contain significant amounts of SO_3 and recent confirmation of the effect of close combustion control on SO_3 formation would appear to stress the importance of oxygen concentration. Methods of measuring SO_3 content are also reviewed.

The physical aspects of deposits in boilers and gas-turbine systems discussed by Ungar and Putnam in Chapter 3 deal with an aspect of this general problem which time may prove to have been

rather neglected up to now. This chapter should at least stimulate further research into this approach.

Chapter 4 by Krause covers external or fire-side deposits and is a valuable survey of a rather untidy and wide subject. The lack of any coherent theme linking experience and research from investigation to investigation is apparent; methods of reducing deposits which have worked in one case have failed in another and the author does well to emphasise that the universal solution to deposit formation has still to be found. Slunder, in Chapter 5, discusses the increasingly important topic of high-temperature corrosion, particularly that due to alkalies, chlorides, sulphur oxides and vanadium compounds at temperatures above 1200 F. The two most serious sources of trouble would appear to be high sulphur coals containing an appreciable amount of chlorine and, with oil firing, vanadium.

Low-temperature corrosion is dealt with by Miller in Chapter 6 and, while this chapter gives a logical outline of this subject, it is probably the least exhaustive in the book. Measurements of acid attack using either the "rate of build-up" technique with the dewpoint meter or, more directly, cooled "corrosion" probes are not reported, neither is the work on airheater metal temperature distribution and means of altering same. These and other omissions may have been deliberate as, of all aspects of the overall problem, low-temperature corrosion can now be claimed to be most clearly understood. For completeness, however, and for the information of those still engaged in this problem, this chapter could have been expanded.

The last chapter, by Hummell, is concerned with the removal of solids from combustion gases. The effect of fly ash on erosion of gas-turbine blades and in forming airheater deposits is discussed and descriptions of cyclone and electrostatic precipitators given.

These seven reviews are prefaced by a general introduction by Landry which deserves special mention. His purpose is to draw attention to the lines of research still to be carried out in this program and he achieves a fresh and stimulating approach to the problem as a whole which should encourage all workers in this field. His point that a boiler or gas turbine is, under normal conditions, a poor ash collector is pertinent; but it does suggest that for completeness, some mention should be made of the fact that what ash—and obnoxious gases—is not caught in the boiler or gas-turbine system passes into the atmosphere and gives rise to another set of problems. G. G. Thurlow, England

1437. Poulston, B. V., Combustion studies in a transpiration-cooled gas-turbine combustion chamber, *J. Inst. Fuel* **32**, 221, 279–287, June 1959.

The principles of effusion cooling have been applied to a practical industrial gas-turbine combustion chamber in the form of the "louvred" wall construction. A research combustion chamber of this kind, and the apparatus and techniques used for studying its performance are described. The chamber incorporates a swirler/shroud flame stabilizer and simplex pressure-jet atomizers. After considering the general combustion characteristics of this type of stabilizer, the research results are discussed from the point of view of discovering the precise effect of the air which passes through the "louvred" walls. This air, in addition to cooling the walls, mixes with the air surrounding the flame and influences combustion. The effect depends upon the relative air quantities and velocities. Conditions can be such that there is little turbulence on the periphery of the flame and combustion quality may suffer. If the cooling air is adjusted to avoid this condition, mixing and turbulence will increase locally so that combustion improves. This, however, may result in an increased heat transfer to the walls beyond the capacity of the cooling air to keep the wall temperature at its optimum value.

From author's summary

1438. Martin, D. G., and Webb, J. D., Simulation of combustion chamber performance: Examination of the predictions of an analogue of a high intensity combustion chamber, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 651–653.

The stability limits of annular baffle flame holders of various sizes for the premixed propane-air flames were measured and compared with the results obtained formerly by the "cold" analog of geometrical similarity. Data of the analog are due to Spalding and Senior [*Proc. Instn. Mech. Engrs.* **171**, p. 383, 1957]. Predictions of the analog were proved to be qualitatively correct, at least for the single-stream combustion chambers.

T. Hikita, Japan

1439. Predvoditelev, A. S., Theoretical examination of vibratory movement of the flame front in closed vessels, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 779–782.

Author considers two observed phenomena: (1) the distortion of a flame front in a tube by acoustic waves and (2) the increase in vibration frequency of a flame front as it progresses. First phenomenon is shown by series of flash photographs, and explanation is given based on nonlinear acoustics equation and Eckert's treatment of viscosity. Latter phenomenon is also demonstrated photographically, and expression for vibration frequency of flame front is derived. Comparison of calculated frequencies with experimental values, using Popov's data, is made.

J. C. Truman, USA

1440. Agosta, V. D., and Baker, H. D., Temperature determinations of methane-air combustion products by velocity-of-sound measurements, Proc. Sixth Midwest. Conf. Fluid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 303–319.

Paper describes a method for determining the temperature of gases by measuring the velocity of sound in the medium. Both thermodynamic equilibrium and nonthermodynamic equilibrium conditions are considered. The velocity of sound is measured by recording the time required for a spark-generated sound wave to travel to an electrically charged gap. The system is similar in principle to that described by Suits and Paritsky, [*Physics* **6**, p. 190, 1935 and *Proc. Nat. Acad. Sci.* **21**, 1935]. The theory is described and treated analytically in some detail.

Good agreement was found in checking the system against a thermocouple in a stable nitrogen atmosphere. Temperatures measured during the combustion of methane-air mixtures were in reasonable agreement with the adiabatic flame temperature. Unfortunately, difficulty was experienced in making simultaneous pressure measurements.

Reviewer considers this work a contribution to the development of velocity-of-sound temperature measurement, which has received too little attention in the past. D. Bendersky, USA

1441. Vlasov, K. P., and Kokushkin, N. V., On errors committed in flame temperature measurements in flow using thermocouples (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 8, 137–141, Aug. 1957.

Using a turbulent flame of benzine-air at a flow rate of 50 m/sec, a variation in temperature of 150–250 C was found at 700 C. This variation is explained by assuming a chemical reaction at the thermocouple junction. As a result it is recommended that an average or mid-point temperature be taken as the thermocouple is rotated through 180° in the gas stream.

J. H. Davidson, India

1442. Kunugi, M., and Jinno, H., Measurements of fluctuating flame temperature, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 942–948.

The spectrum of temperature fluctuation in both turbulent and laminar diffusion flames is examined using a small unshielded thermocouple, compensation for the theoretical dynamic response of which is applied by means of a frequency-compensating network.

Results are presented as a frequency spectrum of temperature amplitude, and surprisingly similar results are obtained for laminar and turbulent cases.

The method is open to some criticism, notably the use of an unshielded thermocouple and the use of frequency corrections based only on theoretical response of the thermocouple. Nevertheless it has been possible to show the existence of regions of different frequencies of oscillation in different parts of the flame.

D. G. Stewart, Australia

1443. Holderness, F. H., and MacFarlane, J. J., The continuous flow instrumental analysis of flame gases, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 923–928.

Prime Movers and Propulsion Devices

(See also Revs. 1078, 1365, 1418, 1426, 1500)

1444. Fowler, J. E., and Brandon, R. E., Steam flow distribution at the exhaust of large steam turbines, ASME Semiann. Meet., St. Louis, Mo., June 1959. Pap. 59-SA-62, 11 pp.

1445. Edkins, D. P., Why free turbines?, *Aero/Space Engng.* **18,** 8, 58–63, Aug. 1959.

1446. Mead, G. A., Compression sensitivity of monopropellants, *ARS J.* **29,** 3, 192–198, Mar. 1959.

A method for evaluating the sensitivity of liquid monopropellants to initiation of decomposition in the presence of rapidly compressed gas bubbles has been developed. The mechanical design of the equipment and the conditions of experimentation simulate the environment which can occur in actual propellant systems. During the test, a gas bubble in contact with a liquid monofuel sample is compressed rapidly by a gas-driven piston. The mass and velocity of the piston are analogous to the mass and velocity of a liquid propellant flowing in an actual propellant system against a dead end. It is postulated that the significant parameter to be associated with decomposition initiation by this type of stimulus is the minimum compressive energy per unit gas bubble volume. A theoretical analysis and experimental data for several monofuels are given in support of this hypothesis. The process of data reduction is described.

From author's summary

1447. Gordon, S., and McBride, Bonnie J., Theoretical performance of liquid hydrogen with liquid oxygen as a rocket propellant, NASA Memo 5-21-59E, 139 pp., June 1959.

Using the usual assumptions of isentropic one-dimensional expansion from thermodynamic equilibrium conditions in the chamber to ambient pressure and to vacuum, the performance of liquid hydrogen-liquid oxygen propellant combination was calculated for chamber pressures 60, 150, 300, and 600 psia, pressure ratios 1 to 4000, and oxidizer-fuel ratios 1.190 to 39. 683. Quantities calculated were I_{sp}, T_c, T_e, c^*, C_F, A_e/A_t, c_p, M, viscosity, thermal conductivity, and equilibrium gas compositions. Both equilibrium and frozen composition nozzle expansions were calculated. Results are presented in graphical and tabular form.

A. Fuhs, USA

1448. Newgard, J. J., Utilization of stored energy in solid material as an added energy source, *ARS J.* **29,** 8, 603–604 (Tech. Notes), Aug. 1959.

1449. Gall, J. F., Recent advances in flourine chemistry and technology, *ARS J.* **29,** 2, 95–103, Feb. 1959.

1450. Charwat, A. F., Photochemistry of the upper atmosphere as a source of propulsive power, *ARS J.* **29,** 2, 108–114, Feb. 1959.

Due to ultraviolet solar radiation a large percentage of the oxygen in the chemosphere from 110 to 150 Km is dissociated. The temperature of the gas in this region being between 250 to 410 K, the atomic oxygen would recombine when shielded and release a large amount of heat per pound of oxygen formed.

Usage of this heat for propulsion in a ramjet is studied for ranges of interest of the significant parameters such as altitude, flight Mach number, diffuser efficiencies and pressure ratio, and an optimistic recombination rate constant. The thrust F per frontal area A reaches a maximum around $M = 2$ because the recombination rate declines rapidly with increasing temperature. The value of this maximum of F/PA, where P is the ambient pressure, might be as high as 3, which corresponds to a thrust less than 10^{-3} lb/ft^2 at the optimum altitude, which is hardly enough to sustain a structure with known materials.

Reviewer finds that the presented charts are well documented.

H. P. Eichenberger, USA

1451. Green, L., Jr., and Carter, J. M., Performance calculations for hybrid nuclear-chemical rocket propulsion systems, *ARS J.* **29,** 3, 180–186, Mar. 1959.

Preliminary preformance calculations for propulsion systems in which water and light metal propellant components are vaporized by nuclear heat prior to chemical reaction indicate that the hybrid system can remove limitations due to high heats of vaporization on the capacity of light metals to generate combustion products with high available enthalpy, and avoid the limitations placed on gas temperatures achievable by pure heat-transfer systems by material strength requirements. The hybrid system can thus reconcile high specific impulse performance with high propellant density and avoid the use of cryogenic propellants. A semiquantitative comparison of the relative cost and feasibility of achieving a given flight performance with various propellant systems indicates that the hybrid water-metal systems compare favorably with high-energy chemical and pure heat-tranfser systems. A qualitative discussion of the engineering difficulties faced by the various nuclear systems indicates that, by virtue of avoiding the material protection problem, development of a low-cost hybrid water-magnesium system requires no major technological advances beyond today's achievement, although systems employing lithium promise higher performance. It is concluded that the indicated performance achievable with hybrid systems is attractive enough to warrant more detailed consideration of such systems for possible application to ambitious missions.

From authors' summary

1452. Goldsmith, M., Augmentation of nuclear rocket specific impulse through mechanical-electrical means, *ARS J.* **29,** 8, 600–601 (Tech. Notes), Aug. 1959.

1453. Wilson, V. C., The thermionic converter, ASME Semiann. Meet., St. Louis, Mo., June 1959. Pap. 59-SA-23, 8 pp.

A thermionic converter is a vacuum or gas-filled device with a hot electron emitter and a cold collector. Heat lifts some of the electrons in the emitter to a high potential position outside the emitter. If the electrons are collected on a metal with a low work-function surface, some of this potential may be conserved to drive

the electrons in an external circuit to do useful work. Space charge between the electrodes may be reduced by close spacing or by neutralization by positive ions. Calculations have been made to determine the optimum conditions to obtain maxiumm power outputs and maximum efficiencies. Theoretical and experimental results for the closely spaced vacuum converter and for two methods of operating the gas-filled converters are given. Some possible applications are discussed.

From author's summary

1454. Wilson, V. C., Conversion of heat to electricity by thermionic emission, *J. Appl. Phys.* **30,** 4, 475–481, Apr. 1959.

1455. Zwick, E. B., and Zimmerman, R. L., Space vehicle power systems, *ARS J.* **29,** 8, 553–564, Aug. 1959.

1456. Jones, K., Secondary power in advanced flight vehicles, *Aero/Space Engng.* **18,** 8, 54–57, 63, Aug. 1959.

Magneto-fluid-dynamics

(See also Rev. 1363)

1457. Newcomb, W. A., Magnetic differential equations, *Physics of Fluids* **2,** 4, 362–365, July–Aug. 1959.

Paper is an extension and correction of the paper of Kruskal and Kulsrud [*Physics of Fluids* **1,** 4, 265–274, 1958; AMR **12** (1959), Rev. 5257] concerning the differential equations of perfectly conducting plasmas in mechanical equilibrium with magnetic fields. The surface of constant plasma pressure was shown to be a topological torus in cited paper. In the present paper are developed the necessary and sufficient conditions for the magnetic differential equations used by Kruskal and Kulsrud. An equation covering these conditions is offered as a substitute for one appearing in the earlier paper, together with other consequent corrections. Engineers will find this paper difficult to read unless they are well-versed in vector notation equations describing ionized gas flow in magnetic fields. R. J. Mindak, USA

1458. Rossow, V. J., On series expansions in magnetic Reynolds number, NASA TN D-10, 44 pp., Aug. 1959.

Method of finding magnetohydrodynamic flow solutions by expansion of the flow parameters in a power series of magnetic Reynolds number R_m is discussed. Characteristics of the solutions so obtained are illustrated by following examples: (1) for small R_m (inviscid channel flow with finite magnetic field); (2) for small or for large R_m (steady two-dimensional flow of incompressible viscous fluid through an infinitely long channel with uniform transverse magnetic field); (3) for large R_m (channel flow starting impulsively, with or without viscosity). Expansion in positive powers is a straightforward but tedious process, in negative powers it is not so tedious but may not give realistic results for terms of order higher than the first.

From author's summary by R. Nardini, Italy

1459. Globe, S., Laminar steady-state magnetohydrodynamic flow in an annular channel, *Physics of Fluids* **2,** 4, 404–407, July–Aug. 1959.

Subject problem is analyzed for incompressible flow with constant scalar conductivity and permeability and neglecting free charges. The problem is analytically very simple when the flow is assumed laminar. Author attempts to show rigorously that the electromagnetic properties are independent of the streamwise coordinate. While the answer is convincing the proof is not. Equation [10] in this proof is incorrect because the variation of H_x with radius has been omitted. S. H. Maslen, USA

1460. Atkinson, W. R., Holden, W. R., and Fowler, R. G., Shock waves reflected by magnetic fields, *J. Appl. Phys.* **30,** 6, 801–802, June 1959.

Fast-moving plasmas encountering transverse magnetic fields of order 10^4 gauss are decelerated so rapidly as to produce reflected shock waves. Observations in hydrogen at gas pressures of 1 to about 10 mm Hg are analyzed. There are critical conditions of magnetic field for the onset of the reflection. The velocities of the advancing and reflected waves are recorded as a function of pressure and field. From authors' summary

1461. Meyer, R. X., Magnetohydrodynamics and aerodynamic heating, *ARS J.* **29,** 3, 187–192, Mar. 1959.

As an example of the solution of the equations of incompressible magnetohydrodynamics, the problem of axisymmetric stagnation point flow is solved numerically both for diffusivity ratios $\mu\sigma\nu$ of zero and unity. This is a case of the class of solutions discovered by C. C. Lin [AMR **12** (1959), Rev. 3098]. The effect on heat transfer to the wall is deduced.

Author then considers the values of the relevant parameters attainable with reasonable field strengths behind bow shocks on hypersonic missiles. Electrical conductivities at temperatures up to 24,000 K are estimated, assuming thermal equilibrium, making plausible assumptions regarding cross sections and ignoring gyration of charged particles.

Experiments on glow discharges in supersonic streams are reported briefly. J. A. Shercliff, England

1462. Akhiezer, A. I., Liubarskii, G. Ia., and Polovin, R. V., The stability of shock waves in magnetohydrodynamics, *Soviet Phys.-JETP* **8,** 3, 507–511, Mar. 1959. (Translation of *Zh. Eksp. Teor. Fiz., Akad. Nauk SSSR* **35,** 731–737, Sept. 1958 by Amer. Inst. Phys., New York, N. Y.)

Author investigates the problem of the stability of plane magnetohydrodynamic shock waves by means of small perturbations which depend only on the distance of the surface of discontinuity and on time. Analysis shows that magnetohydrodynamic shock waves can be unstable and must disintegrate into several shock waves if the total number of magnetohydrodynamic, magnetoacoustic and entropy waves emanating from the front of the discontinuity is not equal to six. It is shown also that the direction of the magnetic field can modify the region of stability.

Y. H. Kuo, China

1463. Golitsyn, G. S., and Staniukovich, K. P., Some remarks on the structure of shock waves, *Soviet Phys.-JETP* **8,** 3, 575–576 (Letters to the Editor), Mar. 1959. (Translation of *Zh. Eksp. Teor. Fiz., Akad. Nauk SSSR* **35,** 828–830, Sept. 1958 by Amer. Inst. Phys., New York, N. Y.)

It is known that, in a gas with high thermal conductivity and negligible viscosity, the entropy goes through a maximum and in that case the speed of sound in the system of coordinates associated with the discontinuity is equal to the local speed of sound. In this note, author observes that this phenomenon occurs also in other cases. For instance in magnetohydrodynamics, Joule heating and thermal conductivity of the gas can also bring the entropy to a maximum. He observes also that the increase of electric conductivity increases the gradient of entropy and, hence, decreases the width of the transition zone. Y. H. Kuo, China

1464. Syrovatskii, S. I., The stability of shock waves in magnetohydrodynamics, *Soviet Phys.-JETP* **8,** 6, 1024–1027, June 1959. (Translation of *Zh. Eksp. Teor. Fiz., Akad. Nauk SSSR* **35,** 1466–1470, Dec. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Author considers the stability of shock waves in magnetohydrodynamics by means of a special theoretical model in which there occurs a spontaneous emission from a shock wave of waves of

infinitesimal small amplitudes. A small perturbation can be represented in form of the superposition of waves of four types: fast and slow magneto-acoustical waves, a magnetohydrodynamic wave and an entropy wave. In the present case, author considers the interaction of oblique shock waves with magnetohydrodynamic waves of small amplitude. Boundary conditions refer to the perturbations of the velocity and magnetic field intensity. Perturbations are assumed in the usual exponential form, and the expressions for the frequency and velocity of magnetohydrodynamic waves were taken from author's previous paper [*Usp. Fiz. Nauk* **62**, p. 247, 1957] and from the book by L. D. Landau and E. M. Lifshitz ["Electrodynamics of continuous media," Moscow, GITTL, 1956].

As the first case the author discusses a spontaneous emission of weak magnetohydrodynamic waves of small amplitude from the shock. Two subcases are possible: Three emitted waves or less than three. The result is that only a compression wave is stable to spontaneous emission of magnetohydrodynamic waves. The author maintains that there is no need for consideration of all possible waves of small amplitude; this follows from entropy changes across a shock wave. The next problem considered is that of collision between a shock wave and a weak magnetohydrodynamic wave approaching it. The result is that such a wave produces a finite change in the original flow, which either leads to disintegration of the shock wave into several new shock waves or to a nonstationary flow of the medium. The first case cannot eliminate the instability of the system, since the ensemble of disintegrated shock waves is again unstable relative to a magnetohydrodynamic perturbation. Author concludes that a shock wave is converted into certain nonstationary flow under the action of infinitely small perturbations.

M. Z. v. Krzywoblocki, USA

1465. Wu, C.-S., and Hayes, W. D., Axisymmetric stagnant flow of a viscous and electrically conducting fluid near the blunt nose of a spinning body with presence of magnetic field. Part I. Exact solution of incompressible and constant-properties model, AFOSR TN 58-405 (Princeton Univ., Dept. Aero. Engng. Rep. 431; ASTIA AD 159 208), 46 pp., Apr. 1958.

This is the first part of a series of studies of the stagnation point flow of a viscous and conducting fluid near the blunt nose of a moving and spinning body in the presence of magnetic field. The body under consideration is axisymmetric and the fluid is assumed to be incompressible and has constant physical properties. Exact similar solution is verified in existence. The final differential systems contain one principal system and two subordinate systems. Only general discussions are given in this report.

From authors' summary

1466. Wu, C.-S., Axisymmetric stagnant flow of a viscous and electrically conducting fluid near the blunt nose of a spinning body with presence of magnetic field. Part II. Consideration of realistic conditions: Compressible viscous layer and small magnetic Reynolds number, AFOSR TN 58-711 (Princeton Univ., Dept. Aero. Engng. Rep. 431; ASTIA AD 162 246), 37 pp., Sept. 1958.

This is the second part of the present study of the axisymmetric stagnation point flow of a viscous and conducting fluid near a spinning body. A more realistic physical model is adopted in the present case. The compressibility and variable physical properties are taken into consideration. In the viscous layer, boundary-layer approximation is employed. Again, since magnetic Reynolds number is postulated to be small, mathematical simplification of the induction equations is obtained.

From author's summary

1467. Ludloff, H. F., Magnetic boundary layer, *ARS J.* **29**, 8, 590-591 (Tech. Notes), Aug. 1959.

Velocity field of two-dimensional supersonic flow of a conducting fluid past a thin airfoil carrying a weak magnetic field can be determined by solving a linearized momentum equation after the magnetic field has been determined from the linearized induction equation. The solution of the latter equation in terms of modified Bessel functions indicates that the magnetic field that is axisymmetric about the airfoil when the magnetic Reynolds number is vanishingly small (i.e. without fluid flow) is blown downstream to form a thin "magnetic boundary layer" for large magnetic Reynolds number. This insight illustrates the often-quoted theorem that the magnetic flux is partly carried with the fluid and partly dissipated through it.

I. Tani, Japan

1468. Senior, T. B. A., Diffraction by an imperfectly conducting wedge, *Comm. Pure Appl. Math.* **12**, 2, 337-372, May 1959.

Author considers the problem of an electromagnetic wave incident upon a wedge whose conductivity is large but not infinite. Previous solutions of this problem proved to be unsatisfactory. The basis of the author's method is one developed by A. S. Peters for the exact solution of a mixed boundary-value problem in hydrodynamics involving the equation $\Delta^3\phi - k^3\phi = 0$. By means of the Laplace transform, the electromagnetic wave boundary-value problem is transformed into one involving a difference equation for the determination of an analytic function whose real part represents the velocity potential. Although the method used is essentially that of Wiener-Hopf, it is of wider scope since it is not necessarily restricted to cases involving discontinuities in parallel planes.

Reviewer believes that the method presented here increases significantly the number of problems in electromagnetic wave theory that can be solved analytically.

E. J. Scott, USA

1469. Sawyer, G. A., Scott, P. L., and Stratton, T. F., Experimental demonstration of hydromagnetic waves in an ionized gas, *Physics of Fluids* **2**, 1, 47-51, Jan.-Feb. 1959.

Hydromagnetic oscillation in a linear discharge tube with metal walls in the presence of an externally applied axial magnetic field is investigated. Two types of magnetic probes, a small-diameter coil and a semicircular loop of wire enclosing one-half of the discharge tube, are mainly used to determine the character of the discharge. It is shown that a regular helical oscillation occurs when the discharge current falls below 10^4 amp. Spectroscopic measurement across the tube diameter shows no Doppler shift, and the rotation of the plasma as a whole is estimated to be less than 10% of the observed rotation. Thus the oscillation is considered to be a form of hydromagnetic wave propagating in the axial and circumferential directions, which is produced by the radial oscillation of the plasma. This idea seems to be supported also by the fact that the frequency of oscillation is inversely proportional to the square root of the pressure or the atomic weight of the gas.

F. Tamaki, Japan

1470. Liubarskii, G. Ia., and Polovin, R. V., Simple magnetosonic waves (In Ukrainian), *Ukrain. Fiz. Zh.* **3**, 5, 567-570, 1958. (Translation by Morris D. Friedman, Inc., P. O. Box 35, W. Newton, Mass., Pap. L-123, 4 pp.)

It is shown that, just as in ordinary gasdynamics, the phase velocity of simple magnetosonic waves increases as the density increases under compliance with

$$[v_{pp}]_s > 0$$

This fact is used for a qualitative investigation of time variation of simple waves. Conditions are found for formation of discontinuities, which agree with a known gasdynamics criterion, too. It is shown that self-similar waves are always rarefaction waves. Time dependence of density is given in a Lagrangian representation.

From authors' summary by P. G. Schwaar, USA

1471. Coensgen, F. H., Cummins, W. F., and Sherman, A. E., Multistage magnetic compression of highly ionized plasma, *Physics of Fluids* **2,** 4, 350–361, July–Aug. 1959.

The mean energy of the charged particles of a plasma which is confined in a magnetic field may be increased by increasing the magnitude of the magnetic field in a time which is short with respect to the ion relaxation time (magnetic compression). It is shown that the necessary stored energy can be reduced and the efficiency greatly increased if the magnetic compression is performed in several stages, such that the plasma is compressed and transferred to successively smaller volumes. The predicted transfer behavior has been confirmed by studying the plasma movement in a three-stage system. In the course of the investigation a plasma source has been developed which provides bursts of plasma of 10^{14} to 10^{18} ions with an average velocity of the order of 10^7 cm/sec. From authors' summary by R. Betchov, USA

1472. Goulard, R., Optimum magnetic field for stagnation heat transfer reduction at hypersonic velocities, *ARS J.* **29,** 8, 604–605 (Tech. Notes), Aug. 1959.

The application of a magnetic field to the stagnation area of a blunt body has two contrary effects: It reduces convective energy transfer, but increases radiation energy transfer. Consequently, for very high speeds, when this latter effect is existent but not dominant ($q_R^{(o)} < 0.4\, q_c^{(o)}$), an optimum magnetic field exists which insures minimum energy transfer. At still higher speeds, radiation is dominant, and the application of a magnetic field always increases the energy transfer to the stagnation area or the nose. This argument closely parallels the well-known argument on the existence of an optimum radius. The existence of an optimum magnetic field is shown, in fact, to depend on the choice of a nose radius below its optimum value.

From author's summary

1473. Dessler, A. J., Ionospheric heating by hydromagnetic waves, *J. Geophys. Res.* **64,** 4, 397–401, Apr. 1959.

The rate of energy dissipation per unit volume is investigated for hydromagnetic waves traveling downward through the ionosphere. A calculation of the heating rate is made, based on assumptions as to the amplitude and Fourier spectrum of the hydromagnetic waves. It is argued in a general way that the peak heating rate due to hydromagnetic waves occurs near 175 kilometers. The results, which are strongly dependent on the assumed values for the amplitude and Fourier spectrum of the hydromagnetic waves, indicate that hydromagnetic heating is normally not important in determining the temperature of the F region. However, during a magnetic storm, the hydromagnetic heating may become the dominant source of heat in the F region. The suggestion is made that the observed lifting of the F region during a magnetic storm is due to an increased heating rate caused by the storm-generated hydromagnetic activity. It is shown that it is not possible to account for the main phase of a magnetic storm by ionospheric heating. From author's summary

1474. Bernstein, W., and Kranz, A. Z., Ohmic heating in the B-1 stellarator, *Physics of Fluids* **2,** 1, 57–61, Jan.–Feb. 1959.

This paper presents a detailed comparison between ohmic heating theory and the experiments made on the B-1 stellarator over a wide range of axial magnetic confining field, electric heating field and helium pressure. It is found that, in the early stage of the discharge, agreement between theory and experiment is good, and the predicted scaling laws are valid. However, experimentally it is found that it takes about 5 times longer to complete first ionization than predicted. Also, the current is seen to level off at a plateau at a time when theory predicts a continuous heating. These discrepancies are attributed to three energy sinks: cold neutral particles entering the discharge, runaway electrons leaving the discharge and radiation from impurities. In addition, the electron density is observed to decrease during the discharge (pump-out). For the early current plateau observed at low ratios of heating field to pressure, it appears that the plasma density is about 15% less at 18,000 gauss than at 27,000 gauss as a result of this pump-out. Further, it is suggested that Kruskal's hydromagnetic instability results physically in an increased rate of diffusion.

From authors' summary by F. Tamaki, Japan

1475. Nakagawa, Y., Theoretical and experimental study of heat transfer by cellular convection in the presence of impressed magnetic fields, Proc. Sixth Midwest. Conf. Fluid Mech., Austin, Texas, Sept. 1959; Austin, Texas, Univ. Press, 1959, 417–426.

Results are given for the heat transfer by combined conduction and cellular convection through a horizontal layer of electrically conducting fluid. In the experiments a mercury layer was used, with the lower bounding surface heated, and the upper one cooled, by constant temperature baths. The mercury chamber was placed in a vertical magnetic field. The heat flow through the layer is given as a function of Rayleigh number. Very good agreement with theory is obtained in the range up to twice the critical Rayleigh number given by the linear theory for marginal stability.

R. Siegel, USA

Aeroelasticity

(See also Rev. 1163)

1476. Rogallo, V. L., and Yaggy, P. F., A wind-tunnel investigation of the stall-flutter characteristics of a supersonic-type propeller at positive and negative thrust, NASA Memo 3-9-59A, 66 pp., May 1959.

Propulsive thrust and power characteristics were obtained in addition to thrust and torque distributions. The inflow velocity was also measured. Flutter characteristics were obtained at both positive and negative thrust conditions and with the thrust axis inclined. A correlation is made of the flutter stresses and aerodynamic section thrust characteristics.

From authors' summary

1477. Miles, J. W., and Rodden, W. P., On the supersonic flutter of two-dimensional infinite panels, *J. Aero/Space Sci.* **26,** 3, 190–191 (Readers' Forum), Mar. 1959.

1478. Hall, H., and Chapple, E. W., The aerodynamic effects of aspect ratio on control surface flutter, Aero Res. Counc. Lond. Curr. Pap. 434, 16 pp., 1959.

Report describes a series of low-speed flutter tests to obtain a direct measurement of the aerodynamic effects of aspect ratio on wing-aileron flutter. The tests were made on rigid wings fitted with full span ailerons, the wings having root flexibilities in roll and pitch. Provision was made for mass-balancing the ailerons. Some general conclusions are drawn concerning the effects of aspect ratio and mass balance on control surface flutter.

From authors' summary

1479. Loiseau, H., Calculations and tests on flutter in a wind tunnel and in free flight on similar wings (in French), *Rech. Aéro.* no. 63, 13–18, Mar.–Apr. 1958.

A wing and aileron were allowed to flutter with two degrees of freedom (wing flexure and aileron rotation) both in a wind tunnel and on free-flying model. The calculated flutter speed was 10% greater than that in the wind tunnel and 5% less than that in free air. Difference is possibly due to turbulence and lack of damping in tunnel. Aileron buzz (at speeds outside the flutter range) was observed in flight, but was not noticed in the wind tunnel.

A. W. Babister, Scotland

1480. Kilpatrick, D. A., and Burrows, R. A., Aspect-ratio effects on compressor cascade blade flutter, Aero. Res. Counc. Lond. Rep. Mem. 3103, 7 pp., 1958.

This report gives the results of cascade tests on blades of aspect ratio varying from 3.0 to 1.5, with particular reference to stalling flutter. It is concluded that the influence of aspect ratio on stalling flutter cannot be simply formulated but depends largely on the particular blade design. The effect on the magnitude of the flutter stresses is not critical although the curves do show a tendency to flattening at an aspect ratio about 2.0 (height/thickness ratio of 20), indicating that the advantages of further reduction in aspect ratio are relatively small. The "critical flutter velocity" is more complex. For the "low" to "moderate" stress levels the increase of critical flutter velocity, with decreasing aspect ratio, occurs quite gradually, while for the high stress levels the increase is very much greater, and is in fact itself quite critical.

From authors' summary

1481. Smith, F., and Hicks, W. D. T., The R. A. E. electronic simulator for flutter investigations in six degrees of freedom or less, Aero. Res. Counc. Lond. Rep. Mem. 3101, 62 pp., 1959.

This report describes the design and construction of an electronic simulator for flutter investigations in any number of degrees of freedom not exceeding six. The principles of the simulation are discussed, and the actual circuits of the machine are described in some detail for those wishing to build similar machines.

The advantages and limitations of this method of solving flutter equations are considered, and other developments and applications are discussed. From authors' summary

Aeronautics

(See also Revs. 1074, 1080, 1336, 1493, 1510)

1482. Andrei, St., Pneumatic drive of helicopter rotors in hovering flight (in Roumanian), *Studii Si Cerţări Mecan. Appl.* **10,** 2, 393–413, 1959.

Author discusses the variation of the total efficiency, of the net power, of the fuel consumption, and of the torque as functions of the ratio of the jet velocity to the corresponding tip velocity. In the expressions of these magnitudes, the influence of the kinematic parameters is separated from that of the internal aerodynamic parameters. A few general aspects of the pneumatically driven helicopter and the effect of reheat on its efficiency are then presented. M. Ionescu, Roumania

1483. Nichols, J. B., Product analysis of tilt-wing propelloplane type VTOL aircraft, ASME Semiann. Meet., St. Louis, Mo., June 1959. Pap. 59-SA-35, 9 pp.

1484. Hoffman, M. A., and Pastan, H. L., Automatic range prediction in flight, *Aero/Space Engng.* **18,** 8, 47–53, Aug. 1959.

The parameters of fuel quantity, altitude, ambient air temperature, and wind must be taken into consideration in order to limit range prediction errors to less than 5 or 10%. A diagram of a simple analog-type range computer concludes this paper.

From authors' summary

1485. Gracey, W., and Ritchie, V. S., Review of aircraft altitude errors due to static-pressure source and description of nose-boom installations for aerodynamic compensation of error, NASA Memo 5-10-59L, 9 pp., June 1959.

Aircraft altitude errors due to static-pressure source are briefly reviewed. Wind-tunnel test information concerning nose-boom pressure installations for aerodynamically compensating static-pressure errors due to position and angle of attack at subsonic and low supersonic speeds is also presented.

From authors' summary

Astronautics

(See also Revs. 1071, 1073, 1082, 1285, 1447)

1486. Michael, W. H., Jr., and Tolson, R. H., Three-dimensional lunar mission studies, NASA Memo 6-29-59L, 38 pp., June 1959.

The variations of the trajectories of a lunar rocket are analyzed, varying the initial conditions of position and velocity by the integration of the classical movement equations in three dimensions of the satellite by means of an electronic computer.

The influence of errors committed with projects of a lunar impact and of lunar satellites when firing from the earth is clearly shown in the numerous graphs. The diverse influence of firing errors in the case of movement in two and three dimensions is also discussed. The estimates have been computed with the geographical coordinate of Cape Cañaveral and the lunar perigee instant of September 1959.

F. R. Marsicano, Argentina

1487. Esses, H., Maximum ejection velocity for return from satellite orbits, *ARS J.* **29,** 8, p. 592 (Tech. Notes), Aug. 1959.

1488. Campbell, G. S., Long period oscillations during atmospheric entry, *ARS J.* **29,** 7, 525–527 (Tech. Notes), July 1959.

An approximate theory is presented for the oscillatory characteristics of the long-period motion during atmospheric entry at constant C_L and C_D. Comparison with numerical results for the complete equations of motion indicates that the approximate theory provides an accurate description of the time-varying amplitude decay and frequency during entry.

From author's summary

1489. Roberson, R. E., Time for escape using a succession of small impulses *ARS J.* **29,** 5, 370–371 (Tech. Notes), May 1959.

1490. Hewitt, M. H., Circular orbit stability in the oblate Earth's equatorial plane, *ARS J.* **29,** 4, 295–296 (Tech. Notes), Apr. 1959.

In the oblate Earth's field, circular equatorial orbits are stable for small planar perturbations. Disturbances causing orbital precession are not considered here since their effects require a consideration of the Earth's noncentral force field, which is outside the scope of the method used in this paper.

From author's summary

1491. Bacon, R. H., Logarithmic spiral: an ideal trajectory for the interplanetary vehicle with engines of low sustained thrust, *Amer. J. Phys.* **27,** 3, 164–165, Mar. 1959.

It is shown that a vehicle with engines of low sustained thrust can by directed along a logarithmic spiral through an inverse-square gravitational field by means of an extremely simple guidance system; it is possible to choose a spiral for which initial and final velocities are optimum.

From author's summary

1492. Bamford, H. E., Jr., An orbital energy indicator, *J. Aero/Space Sci.* **26,** 7, 452–453 (Readers' Forum), July 1959.

An analog indicator display based upon the conservation of a spacecraft's orbital energy is described. The display consists of a single rotating and vertically translating index and three veritcal scales. Altitude, velocity, and orbital energy are indicated simultaneously. The interpretation of the display is illustrated by several examples. From author's summary

1493. Brunner, M. J., Analysis of the aerodynamic heating for a reentrant space vehicle, *ASME Trans.* **81C** (*J. Heat Transfer*), 3, 223–229, Aug. 1959.

Paper is a simplified analysis of aerodynamic heating for reentry trajectories of space vehicles with zero and high lift-drag ratios for both turbulent and laminar flows.

H. G. Lew, USA

1494. McGehee, J. R., Hathaway, M. E., and Vaughan, V. L., Jr., Water-landing characteristics of a reentry capsule, NASA Memo 5-23-59L, 27 pp., June 1959.

A 1/12-scale model and a full-scale capsule were tested to determine accelerations and motions for nominal flight paths of 65° and 90° (vertical), a range of contact attitudes from − 30° to 30°, and a full-scale vertical velocity of 30 fps at contact. Computations for a rigid body were made from equations obtained by utilizing the principle of the conservation of momentum to determine accelerations for a flight path of 90° and a contact attitude of 0°.

From authors' summary

1495. Paulson, J. W., Low-speed static stability and control characteristics of a model of a right triangular pyramid reentry configuration, NASA Memo 4-11-59L, 15 pp., Apr. 1959.

The investigation showed that the model had generally satisfactory longitudinal and lateral static stability characteristics. The maximum lift-drag ratio was increased from about 3 to 5 by boattailing the base of the model.

From author's summary

1496. Schmieschek, U., Theoretical investigations of chemical and physical state of the atmosphere as basis for experimental research of their possible influence on the materials of missiles (in German), Dtsch. Versuchsanstalt Luftfahrt Ber. 95, 38 pp., May 1959.

Taking into consideration the results of measuring rockets' rise effected in the USA after the second World War, information is given on the most important physical characteristics of the atmosphere and on the radiant energetic conditions in the stratosphere and ionosphere. Then the photochemical splitting processes and secondary reactions caused by sun radiation in larger heights are treated. Special details are given regarding ozone formation as well as formation of free oxygen and nitrogen atoms. Finally, the conditions are described to which test chambers and test channels must correspond for examining the coordinating effect of the higher atmosphere at metallic surfaces of missiles.

From author's summary

1497. Loh, W. H. T., Hypervelocity vehicles at large angles of inclination, *ARS J.* **29,** 7, 522-523 (Tech. Notes), July 1959.

1498. Hoffman, G. A., Design of large-area astronautical objects, *Aero/Space Engng.* **18,** 7, 48-52, July 1959.

Possibilities of configurations, materials, and shape-retention techniques are discussed from considerations of weight/area ratio, function, storage, lifetime, and economics.

From author's summary

Ballistics, Explosions

(See also Revs. 1417, 1433, 1503)

1499. Fay, J. A., Two-dimensional gaseous detonations: Velocity deficit, *Physics of Fluids* **2,** 3, 283-289, May-June 1959.

Author proposes theory in which dependence of detonation velocity of gases on diameter of confining tube is attributed to divergence of flow between shock front and C-J plane. Divergence is due to effect of turbulent boundary layer adjacent to wall of confining tube. Because velocity of flow and density are higher in the boundary layer than in the main stream, the fluid in the boundary layer has a larger mass flow per unit area than the main stream. Thickness of boundary layer increases with distance from shock front, so that flow within the main stream diverges. The effect of the boundary layer is expressed in terms of an increase of effective cross-sectional area of the detonation wave.

Equations of continuity, momentum, and energy are those appropriate for quasi-one-dimensional flow in a slowly enlarging channel of cross-sectional area A. The expression for increase of effective area due to the boundary layer is incorporated into the equations. Making use in addition of the equation of state and the C-J condition, expressions for the velocity deficit $(U^\circ - U)/U^\circ$, where U is the observed detonation velocity and U° is the ideal velocity, are obtained in terms of diameter and the effective area increase at the C-J plane. The position of the C-J plane is deduced from a derived expression for a generalized C-J condition, an assumed chemical rate law, and experimental measurements of relaxation distance within the reaction zone.

Computed velocity deficits for stoichiometric hydrogen-oxygen with and without monatomic diluents, hydrogen in air, and acetylene with oxygen differed by from 12 to 41% from observed deficits. Initial pressure was 1 atm and the diameter 2 cm. This is reasonably good agreement. In addition the experimental results which indicate a reaction zone thickness varying inversely with initial pressure for oxy-hydrogen mixtures are in agreement with the measurements of Mooradian and Gordon, which showed velocity deficits to be inversely proportional to the initial pressure, if Fay's theory is accepted.

Marjorie W. Evans, USA

1500. Nicholls, J. A., Dabora, E. K., and Gealer, R. L., Studies in connection with stabilized gaseous detonation waves, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28-Sept. 3, 1958; New York, Academic Press, 1959, 766-772.

Authors experimentally produced detonative combustion behind the shock bottle of an overexpanded nozzle exhaust (containing a hydrogen-air mixture) by preheating the gas so that the normal shock in the flow raised the temperature well above the mixture's ignition temperature. Mixture was produced by injecting pure hydrogen at the nozzle entrance. Experimental details are given. The shock configuration with combustion was very stable and slightly different from the configuration without combustion. Combustion occurred about 25 microseconds after shock compression. Schlieren and direct photographs are shown. Authors point out the difference between their "detonative combustion" and ordinary detonation waves, and also mention the potential usefulness of this "supersonic combustion" in high-speed ramjet applications.

R. A. Strehlow, USA

1501. Troshin, Ya. K., The generalized Hugoniot adiabatic curve, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28-Sept. 3, 1958; New York, Academic Press, 1959, 789-798.

It has been shown that all points on the weak deflagration branch of the Hugoniot curve correspond to real regimes of gas combustion under different conditions of reaction product outflow.

Gas states within unsteady double discontinuities are represented on the P-V plot by points of the curves derived from the generalized Hugoniot equation. These curves start from points on the weak deflagration branch, pass under the conventional Hugoniot curve (its imaginary and energetically forbidden branch for partly compressed detonation) and end at the Jouguet point on the detonation branch.

Plots obtained from the generalized Hugoniot curve seem to confirm that the transition from slow combustion to detonation, occurring through unsteady double discontinuities, is possible only on successive relative acceleration of the flame with respect to gas.

Calculation of gas states from the generalized Hugoniot curve and analysis of schlieren photographs show that flame acceleration with respect to gas is accounted for mainly by development of the flame area due to turbulence of the unburnt gas.

From author's summary by R. Friedman, USA

1502. Shaffer, B. W., Cochin, I., and Mantus, M., Optimum length of a rocket-wall extension beyond its circumferential keyway, *Trans. New York Acad Sci.* (2) **21,** 4, 295–315, Feb. 1959.

For a semi-infinite rocket wall, containing a circumferential keyway and subjected to internal pressure, the elastic deformations are ascertained. It is assumed that the wall thickness is sufficiently small in comparison to the mean radius of the cylinder to make possible the use of shell theory. The study of the problem is based on the discontinuity theory. The rocket wall is separated into three bodies by sections left and right of the keyway. For every part the deformations at the ends are computed. The resultant forces and moments in the sections may be evaluated by imposing the requirement of continuity of deformation at the junctions. The deformations were presented in a form particularly adaptable to numerical calculations. The manner in which discontinuity theory was applied to the axial symmetrical shell problem may be useful in solving other problems in the rocket or pressure-vessel fields. A simple design formula was derived for the length of cylinder from the keyway to the end of the rocket.

L. Foppl, Germany

1503. Gordon, W. E., Mooradian, A. J., and Harper, S. A., Limit and spin effects in hydrogen-oxygen detonations, Seventh Symposium (International) Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 752–759.

Authors observed limits of spin and stable detonations in certain gases as functions of pressure and composition in 20-mm diam detonation tube. Initial pressure range was 0.125 to 3 atm. Initiator was shock wave issuing from a detonating column of $2H_2$-O_2 at any of several pressures ranging from 1.5 to 6.0 times the initial pressure of receiver gas.

Approximate maps in a pressure-composition plane of spin and stable detonation are given for (a) H_2-air (composition range 15 to 18% H_2), (b) O_2-H_2 (for 7 and 8% oxygen and for stoichiometric mixture), (c) $2H_2$-O_2-A (composition range 6 to 12.5% H_2), and (d) $2H_2$-O_2-He (composition range 7 to 12.5% H_2). A table of observed frequencies of spinning detonation is given. Observed frequencies correlate with Fay's theory [J. A. Fay, Thesis, 1951, Cornell Univ.] except for the $2H_2$-O_2 mixtures (theoretical wavelength too long) and the mixtures containing helium. For near limit mixtures a single-headed spin is always observed. As the composition moves away from the limit a double-headed (short wavelength) spin is observed in $2H_2$-O_2-A mixtures. In the helium mixtures, however, as the composition moves away from the limit a long wavelength spin which cannot be accounted for by Fay's theory occurs.

15–85 H_2-air mixture will support detonation with 50 ppm H_2O present but not with 500 ppm.

Temperature of the shock front of the detonation wave is said to be 1100 deg K for all composition limit mixtures.

Marjorie W. Evans, USA

Acoustics

(See also Revs. 1054, 1162, 1174, 1340, 1546)

1504. Paul, D. I., Wave propagation in acoustics using the saddle point method, *J. Math. Phys.* **38,** 1, 1–15, Apr. 1959.

A point source of sound is embedded in one of two semi-infinite media near their plane interface. Adapting the saddle point method used by Banos and Wesley in an analogous case of electromagnetic propagation to the difficult region near the interface, author is able to predict the acoustic field over the whole hemisphere in which the source is located.

The paper is entirely mathematical.

E. G. Richardson, England

1505. Truell, R., Ultrasonic methods and radiation effects in solids, *J. Appl. Phys.* **30,** 8, 1275–1278, Aug. 1959.

Author mentions briefly several known ultrasonic absorption and interaction mechanisms in solids. He then reviews the work of his own group on the effect of nuclear radiation on absorption and velocity dispersion in solids, primarily NaCl. Experimental results are given for attenuation and velocity measurements as a function of time in continuously irradiated strained single crystals of NaCl. Using theoretical relations based on the pinned dislocation loop model, it is possible to estimate the mean loop length and the dislocation density.

The major tentative conclusions are (1) the effect of irradiation is to increase the number of point defects which then act to pin the dislocation, (2) the number of dislocations is not significantly altered by this process.

R. Lyon, England

1506. Burov, A. K., Obtaining high ultrasonic intensities in liquids, *Soviet Phys.-Acoustics* **4,** 4, 326–330, May 1959. (Translation of *Akust. Zh.* **4,** 4, 315–320, Oct.-Dec. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

1507. Callaghan, E. E., An estimate of the fluctuating surface pressures encountered in the reentry of a ballistic missile, NACA TN 4315, 12 pp. + 6 figs., July 1958.

Author bases his analysis on experimental work done by Willmarth entitled "Wall pressure fluctuations in a turbulent boundary layer" and Mull and Algranti entitled "Preliminary flight survey of aerodynamic noise on an airplane wing." The first work was obtained in the walls of a wind tunnel and the second in a wing. In present work it was found that for subsonic flow the pressure fluctuations were proportional to the dynamic pressure. By using this experimental data, the author analyzes the turbulent pressure fluctuations along the nose of a reentry missile and shows that the turbulent fluctuations can be very large. The analysis assumes that the flow in this region is completely turbulent and that the experimental data obtained at low stagnation conditions can be directly extrapolated to reentry stagnation conditions. If this assumption is correct the pressure fluctuations can be of primary importance for practical application.

A. Ferri, USA

1508. Hubbard, H. H., and Maglieri, D. J., The shock wave noise problem of supersonic aircraft, ASME Semiann. Meet., St. Louis, Mo., June 1959. Pap. 59-SA-51, 5 pp.

1509. Koenig, R. J., Noise control measures for jet transport operation, ASME Aviation Conf., Los Angeles, Calif., Mar. 1959. Pap. 59-AV-6, 8 pp.

The control of jet-aircraft noise for the benefit of communities near the airport by engine and engine-suppressor design in combination with flight take-off procedures is discussed. Noise characteristics of the General Electric CJ-805-3 engine with suppressor and the CJ-805-21 aft-fan engine are given. Effect of take-off flight path and engine power on community noise is shown. Noise from engine maintenance testing is discussed. A portable ground runup noise suppressor applicable to such testing is described.

From author's summary

1510. Freeman, N. C., and Lam, S. H., A note on the pressure disturbance at ground level caused by high-flying supersonic aircraft, AFOSR TN 58-1127 (Princeton Univ., Dept. Aero. Engng. Rep. 444; ASTIA AD 207 781), 11 pp., Dec. 1958.

This is a study of the pressure disturbance or bang produced on the ground by a high-flying supersonic aircraft. The main interest here is (1) to assess the effect of the nonuniformity of the atmosphere in attenuating the waves from the aircraft and (2) to relate this to some gross parameters of the aircraft.

The linear supersonic flow theory is used to compute the pressure disturbance at large distance from the aircraft and the attenuation of this disturbance through a Rand standard atmosphere is computed by a simple application of Whitham's theory. Formulas for either a "lift-controlled" or "shape-controlled" bang are given as a function of the gross parameters of the aircraft such as flight Mach number, altitude, size, slenderness ratio, lift coefficient and certain design factors which depend on rather detailed knowledge of the aircraft in question.

From authors' summary

1511. Eshleman, A. L., Jr., Van Dyke, J., Jr., and Belcher, P., A procedure for designing and testing aircraft structure loaded by jet engine noise, ASME Aviation Conf., Los Angeles, Calif., Mar. 1959. Pap. 59-AV-48, 30 pp.

1512. Belcher, P. M., Van Dyke, J. D., Jr., and Eshleman, A. L., Jr., Development of aircraft structure to withstand acoustic loads, *Aero/Space Engng.* **18,** 6, 24–30, June 1959.

The development program for acoustically loaded structure for the DC-8 jet transport is described and new techniques of experimental stress analysis, using a high-intensity siren, are outlined.

From authors' summary

1513. Neimann, G., and Unterberger, M., Reducing gear noise (in German), *Z VDI* **101,** 6, 201–212, Feb. 1959.

Experiments carried out on straight-toothed spur gears concerning the influence of gearboxes, testing shop and lubrication, of speed, load and ratio, of gear-tooth changes and profile machining, together with tooth errors, provide the inital estimate of gear noise to be expected. Frequency analyses and natural vibration measurements of the transmission components are used to substantiate the origin and the frequency position of gear noise.

From authors' summary

1514. Wilson, J., and Resler, E. L., Jr., A mechanism of resonance tubes, *J. Aero/Space Sci.* **26,** 7, 461–462 (Readers' Forum), July 1959.

Micromeritics

(See also Rev. 1557)

Book—1515. DeJuhasz, K. J., Scicchitano, E. A., et al, Spray literature abstracts, New York, American Society of Mechanical Engineers, 1959, viii + 383 pp.

Compilation lists over 1300 articles, papers, books, reports, and other literature items dealing with the scientific, technical and industrial aspects of sprays, as well as associated phenomena and disciplines. The items have been collected from about twenty-four countries and cover the period from about 1880 up to March 1959. The entries cover: the mathematics, physics and chemistry of sprays; the hydro-, aero-, thermodynamics and rheology of sprays; the break-up of liquid stream into drops, and their motion in air, their evaporation and combustion; optical and electronic devices for the experimental study of sprays; branches of mechanical and production engineering entering into the design, production, and testing of pumps, nozzles and other elements of spray generating equipment; borderline and associated disciplines, such as the science and technology of powders and dusts.

The following fields of application are covered: fuel sprays for furnaces, internal combustion engines, gas turbines and rockets; sprays in industrial processes for evaporation drying, humidification, cooling, air-conditioning, and chemical reactions; atmospheric sprays, such as rain, fog, haze, sleet and snow, their formation, evaporation and freezing; agricultural sprays for sprinkling, pest, fungus, and weed control: fire-fighting sprays, as in sprinkler systems and in fire-smothering fogs; aerosols for medical disinfecting, therapeutic, and air-conditioning purposes; sprays and fogs for military purposes in defense and attack. The entries contain full bibliographic data, and in most cases also give concise and detailed abstracts. The affiliation and address of the authors is given in most cases. The book is intended to be a source book on the subject, to aid research workers in their search for previous work related to their problems, to help avoid duplications of effort, and to contact other workers active in related fields.

From authors' preface

1516. Williams, F. A., Spray combustion theory, *Combustion and Flame* **3,** 2, 215–228, June 1959.

The coupled equations of steady-state motion of a statistical group of spherical droplets, coexisting with a multicomponent reacting gaseous medium, are derived, assuming that the induced random fluctuations in the properties of the fluid are negligible. These equations are reduced to a form suitable for describing the one-dimensional flow of a fluid containing a spray which is stationary with respect to the gas. The eigenvalue problem of the burning rate for one-dimensional heterogeneous combustion processes is formulated; an analysis for sprays composed of uniform droplets illustrates the properties of the eigenvalue. The numerical value of the burning velocity for uniform sprays computed from the equation is found to be in approximate agreement with measured experimental values for tetralin, the discrepancy being attributable to the uncertainty of the assumed values, in particular that of the thermal conductivity, and of the specific heat.

This is a serious attempt to determine the burning velocity in a spray (e.g., in a rocket chamber) from the basic properties of the fuel and gas, already yielding a promising accuracy; it can be expected that the accuracy of prediction will increase when the basic properties are known more exactly. Its special merit is that the equations are derived step by step, and the numerous concepts are explained, in order to clarify this abstruse subject as much as possible.

K. J. DeJuhasz, USA

1517. Barth, W., Basic considerations regarding the cleaning effectiveness of water drops (in German), *Staub* **19,** 5, 175–180, May 1959.

Removal of dust from gases by wet cleaning is of great practical importance for several industries. Paper discusses basic investigations on the cleaning effectiveness of water drops and gives a calculating method, the results of which are compared with measured values; on this basis suggestions are given for the design of wet cleaning plants.

Author discusses the aerodynamic interaction between a flowing gas containing dust and a relatively much larger water drop, on the surface of which the dust is precipitated. The path of water drop, introduced into a flowing gas stream in a direction perpendicular to the latter, is determined by means of the Stokes's law on the basis of the aerodynamic drag of the drop at various Reynolds numbers. The concept of "cleaning characteristic" is defined, and is represented in charts as a function of drop diameter, fineness of dust, and gas velocity. The remnant dust content of the gas after the cleaning is calculated. For high cleaning effectiveness author recommends high gas velocity, and an atomization producing droplets in the 0.1 to 0.3-mm diam range. Pertinent literature up to 1958 is listed.

K. J. DeJuhasz, USA

1518. Collacott, R. A., Impact of drops—photographic record of disintegration, *Engineering* **187,** 4856, 440–441, Apr. 1959.

1519. De Corso, S. M., Effect of ambient and fuel pressure on spray drop size, ASME Gas Turb. Power Conf., Cincinnati, Ohio, Mar. 1959. Pap. 59-GTP-3, 9 pp.

Book—1520. Guide to research in air pollution, 3rd ed., (Committee on Air Pollution Controls), New York, The American Society of Mechanical Engineers, 1956, 16 pp. $1.50 (Paperbound)

Pamphlet lists 68 American governmental, academic and private institutions engaged in air pollution and related research. The exact addresses, the names of persons in charge, the sponsoring organization, and the main subjects of research are given.

K. J. DeJuhasz, USA

1521. Granville, R. A., and Jaffrey, W. G., Dust and grit in flue gases, *Engineering* **187,** 4851, 285-288, Feb. 1959.

1522. Dotson, J. M., Factors affecting density transients in a fluidized bed, *AIChE J.* **5,** 2, 169-174, June 1959.

The effects of five operating variables on the uniformity of fluidization in a 4-in. diameter column were determined by a statistically designed experiment. Density fluctuations inside the bed were measured by a capacitance method. Certain parts of the experiment were repeated in a 24-in.-diameter column for comparison with the 4-in.-column data.

In the 4-in. column, gas velocity had by far the greatest effect on uniformity, with uniformity generally decreasing with an increase in gas velocity. This is consistent with the theory that most gas introduced in excess of the ra for incipient fluidization passes through the bed in the form of various-sized bubbles. Better uniformity at the lower bed level indicates that bubbles grow in size as they proceed up the column. An entirely different gas-flow pattern was indicated in the 24-in. column.

From author's summary by S. R. Faris, USA

1523. Wen, C.-Y., and Simons, H. P., Flow characteristics in horizontal fluidized solids transport, *AIChE J.* **5,** 2, 263-267, June 1959.

The flow characteristics of dense solid-gas mixtures transported through horizontal pipes were studied with glass beads and coal powders of various sizes (0.0028 to 0.0297 in.) in 1/2-, 3/4- and 1-in. glass pipes and a 1/4-in. steel pipe. At high solid-gas ratios, the flow of mixtures in transport lines is characterized by a large amount of slippage between gas and solids.

A simple and interesting velocity relationship was noted; the average gas velocity is about twice as large as the average solid-particle velocity. The solid-particle velocities and solid loadings in the pipe line were found to be primary factors affecting pressure drops; the particle sizes and shapes, on the other hand, exerted a very slight effect on the pressure drops. A pressure-drop correlation for the dense solid-gas mixtures is proposed, and applications and limitations of the correlation are shown:

From author's summary by S. R. Faris, USA

1524. Bogardi, J., New contributions to the theory of sediment transportation (in Hungarian), *Hidrológiai Közlöny* **38,** 4, 241-252, Aug. 1958.

1525. Silin, M. O., Kobernik, S. G., and Asaluenko, I. A., Loss of pressure in the motion of water and soil-water slurries in pipe conduits of large diameter (in Russian), *Dop. Akad. Nauk URSR* no. 2, 175-177, 1958; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11122.

Results are given of experiments in the field on the loss of pressure as detailed in the title, the diameters of the pipes being 900, 800, and 614 mm. Tables and graphical relations are furnished showing the dependence of pressure loss on the velocity of the motion, on the diameter of the pipe and the specific weight of the slurry. The steel pipes conveying the slurry were to be classified by their roughness into a separate group of hydraulic smooth steel pipes. Authors also hold the view that the relation $I_g = I_v \gamma_g$ only holds good at low velocities of motion of the water-slurry mixture; at high velocities the values of I_g and I_v become approximate. Here $\overline{I}_g$ and $\overline{I}_v$ correspond respectively to the declinations of the piezometric line during the motion of the slurry and water, while γ_g is the specific weight of the slurry. The experimental data obtained might be applied to the determination of loss of pressure in pipes with diameters of 600 to 900 mm only in the case where the mean diameter of the solid particles approaches 0.1 to 0.5 mm.

N. A. Pritvits

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1526. Abduraupov, R. R., Determination of the slope when bottom deposits are in motion (in Russian), *Dokladl UzSSR* no. 9, 47-50, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11138.

An empirical formula is put forward based on the results of studies of the motion of large particle bottom silt for the determination of the slope of the free surface of the flow in relation to the quantity of deposits being carried along μ, angle of the layer l_l, and the relative roughness of the river bed d/R (d indicates the dimensions of the particles being carried along, R the hydraulic radius). In the experiments, the values of d/R fluctuated between 0.01 to 0.09, while the degree of saturation of the flow by the silt reached 0.1 to 0.25 Kg/m^3.

I. L. Levi

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1527. Sinel'nikov, V. V., An experimental determination of the pressure of a conditional granular medium on a model of a supporting wall with elastic bonds (in Russian), *Trudl Mosk. In-ta Inzh. Zh.-d. Transp.* no. 91, 16-38, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11586.

Results of experiments are furnished on the determination of the pressure of a granular medium on a supporting wall, using a specially designed and constructed device for this purpose. As a granular medium, cylinders 1 and 2 cm in diameter made from alabaster were utilized; these cylinders in the 2-cm diam size had holes through them with a diameter of 1 mm. On this apparatus, with the aid of the cylinders with holes, observations were made on the displacement of the conditional granular medium, and also on the formation of lines of slip when the enclosing wall was rotated. The results of the experiments on the determination of the pressure of the granular medium on the wall are given; also a comparison of the experimental data for the pressure with the calculations made with the Coulomb formula.

I. V. Fedorov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1528. Benedikt, E. T., Scale of separation phenomena in liquids under conditions of nearly free fall, *ARS J.* **29,** 2, 150-151 (Tech. Notes), Feb. 1959.

1529. Litwiniszyn, J., Fundamental principles of the mechanics of stochastic media, Proc. 3rd Congr. Theor. Appl. Mech., Bangalore, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1957; 93-110.

The methods of statistical mechanics and the equations of stochastic processes are applied in the analysis of the phenomena occurring under the influence of the earth's gravity field. The study is carried out for a two-dimensional problem of motion of granular media. The stochastic model is assumed to be an incompressible medium with horizontal homogeneity and symmetry with respect to the vertical axis. The assumption of the superposition principle and the establishment of an integral operator

containing the distribution density function leads to an integral equation. An extension to three-dimensional problems is exemplified.

The description is given of experiments which were carried out to verify the validity of the assumptions made in the theoretical analysis, and corresponding graphs are presented.

W. Ornstein, USA

Porous Media

(See also Rev. 1393)

1530. Paria, G., Deformation of a porous visco-elastic body containing a fluid under steady pressures, *Bull. Calcutta Math. Soc.* **50,** 2, 71–76, June 1958.

Laplace transform has been used by author to determine deformation of porous viscoelastic body (containing fluid) in shape of cylinder for condition of steady pressure applied on boundary through pervious sheath. Value of paper would have been enhanced by numerical or graphical representation of results.

G. G. Meyerhof, Canada

1531. Johnson, E. F., Bossler, D. P., and Naumann, V. O., Calculation of relative permeability from displacement experiments, *J. Petroleum Technol.* **11,** 1, 61–63, Jan. 1959.

A method is presented for calculating individual gas and oil or water and oil relative permeabilities from data obtained during a gas drive or a waterflood experiment performed on a linear porous body. The method has been tested and found both rapid and reliable for normal-sized core samples.

From authors' summary

1532. Khodanovich, I. E., and Nefelova, N. V., The pressure regime in a gas main during filling with gas (in Russian), *Trudi Vses. N.-i. In-ta Prirodn. Gazov* no. 1 (9), 10–16, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7543.

It is shown that while filling a gas main the pressure within it increases with relation to the quantity Q of gas pumped in, the length and diameter of the gas main, and the time t. It is noted that there are two possible methods of filling a gas main with gas: (1) the gas is fed into an unfilled gas main, or into a gas main at atmospheric pressure; (2) the gas is fed into a main filled with gas at a pressure higher than atmosphere. The first case has been theoretically examined by Riband [*C. R. Acad. Sci., Paris,* no. 233, 1951; no. 234, 1952]; Riband obtained the following equations, which determine the pressure P_x and the flow Q_x along a gas main during filling, from the equations of motion and continuity:

$$P_x = P\sqrt[3]{t}\,F(axt^{-3/5}), \quad Q_x = Q\varphi\,(axt^{-2/5})$$

Here x is the distance from the starting point to the section under examination, t is time, P_x and P are the pressures, Q_x and Q are flows, a is a coefficient, and F and φ are certain functions. Engineering equations to determine the quantity of gas flowing through any section of pipeline at a given time, also the pressure at any point in the pipeline, are derived using simplifying assumptions regarding the functions F and φ and certain other assumptions. Example calculations are given. It is pointed out that experimental verification on the Kokhtla-Yarve-Tallin gas main has shown that the calculated and actual pressures are in good agreement. The consumptions of gas along the gas mains were not compared with the calculated figures.

G. E. Khudyakov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1533. Umrikhin, I. D., Investigations on models of the strata of the re-establishment of pressure in gas wells (in Russian), *Gaz. Prom-st'* no. 1, 53–58, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6897.

Results are given of experiments carried out on sand-cement block models of the gas-containing stratum. A significant divergence was disclosed between the factual and theoretical curves, drawn to cover the case of an instantaneous covering up of the wells because of the pressure exercised by the gas contained in the stems of the well-bores. The data for the experiments confirm the excellent precision of I. A. Charnyi's formula ["Subterranean hydromechanics," Gostekhizdat, 1948] and that of A. M. Pirverdyan ["Petroleum underground hydraulics," Aznefteizdat, 1956], which deal with the nonsimultaneous closure of the well.

V. N. Nikolaevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1534. Kisch, M., The theory of seepage from clay-blanketed reservoirs, *Géotechnique, Lond.* **9,** 1, 9–21, Mar. 1959.

The problem considered is that of reduction of water losses from reservoirs by use of a lining of compacted clay. Vertical flow is assumed, and solutions of the equation for steady-state saturated and unsaturated flow through nonhomogeneous soil are obtained. These give the relation between head of water in the blanketed reservoir and seepage loss. The effect of air pressure, greater than atmospheric, of the air trapped below the blanket and the important effect of swelling of the clay are analyzed. The effect of a pervious overlayer placed on the blanket in order to reduce swelling is also considered.

From author's summary

1535. Scott, V. H., and Luthin, J. N., Investigation of an artesian well adjacent to a river, *Proc. Amer. Soc. Civ. Engrs.* **85,** IR 1 (*J. Irrig. Drain. Div.*), 45–62, Mar. 1959.

A pump test of an artesian well in a problem drainage area located adjacent to a river is described. Water moved from the river through a semiconfined aquifer and then vertically upward into the problem area. Pressure conditions within the aquifer vary with changes in river stage resulting from tidal and runoff fluctuation. Calculations of aquifer transmissibilities using established well discharge relationships are made based on analysis of water level recoveries within a tidal cycle. Results indicate that pumping for drainage is not justifiable under these conditions.

From authors' summary

1536. Alikhashkin, Yu. I., A method for calculating the discharge of a pressure inflow into an incomplete well (in Russian), *Vychislit. Matematika* no. 1, 131–135, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11321.

The convergence of the series entering into the expressions for constant filtration-resistance and the mean value of the potential along the opened part of the face is improved by using the Abel-Euler method. Tables and graphs are published which make it possible, for all practical purposes in regard to precision, to calculate the discharge of a well which is incomplete as regards the extent of its opening up.

B. A. Karpyichev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1537. Tepaks, L. A., Hydraulic resistance during turbulent filtration (in Russian), *Trudi Tallinsk. Politekhn. In-ta* **A,** no. 81, 20 pp. + illus., 1956; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6889.

Starting from the premise that "the establishment of the principle of resistance by purely theoretical means appears to be, apparently, an insoluble problem," author nevertheless tries to find a semi-empirical expression in a criterial form. It was established that numerous filtration tests can be reduced to the form of

$$p'R' = A' + \sqrt{B'}\sqrt{p'R'} \qquad [1]$$

where $$p' = \frac{gli}{w^2}, \qquad R' = \frac{wl}{\nu}, \qquad l = \frac{m}{1-m}r$$

l being the hydraulic radius of the pore, m the porosity, r the radius of the solid particles, $w = V/m$ the mean velocity in the pores, A' and B' constants. Further, by working over the results of different tests by this formula, author reaches the deduction that it is only poorly confirmed by experiment, and on this basis tries to determine the critical value of the number R, corresponding to the change-over from the linear resistance to the quadratic. Calculation formulas are given. E. M. Minskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1538. Piskunov, N. S., A method for calculating the exploitation of oil-bearing strata in an elastic regime at assigned depressions (lowering of pressure) in the working and the pressure wells (in Russian), *Trudi Vses. Neftegaz. N.-i In-ta* no. 10, 3–24, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11330.

Problems are investigated on the inflow of liquid from the strata to the working wells and on the output of liquid driven into the stratum through the pressure wells. The distribution of the wells over the oil-bearing stratum is assumed to be arbitrary, the filtration regime elastic. In order to solve the problems, author introduces a system of linear differential equations connecting the increase in output and the fall of pressure in the output. Nothing in the way of hydromechanical concepts in support of the proposed system of equations is advanced; besides, if the distribution of the wells over the stratum is haphazard, the geometry of the system must have a definite bearing on the process of filtration. This difficulty is not taken into account in the proposed system of equations. V. P. Pilatovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1539. Piskunov, N. S., The extraction of oil from oil-bearing strata with water beneath them (in Russian), *Trudi Vses. Neftegaz. N.-i. In-ta* no. 10, 88–100, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7780.

The flow of oil into an uncompleted well sunk in a stratum bounded by a cylindrical supply circumference is examined. The upper part of the stratum contains oil, the lower part water. The oil and water are assumed to be incompressible. Filtration is considered to be steady (the nonsteady problem in the case of an unlimited stratum has previously been examined by the author, *Dokladi Akad. Nauk SSSR (N.S.)* **85,** no. 1, 1952). Conditions of uniform pressure and normal filtration velocity components are assumed to occur at the dividing line between the water and the oil. When the problem is so posed, the water proves to be stationary; the dividing line will be the surface of the current at which the head depends linearly on the Z coordinate; solution of the problem is therefore reduced to determining the motion in one region only (occupied by the oil). A similar condition at the dividing line between two liquids was introduced by P. Ya. Polubarinova-Kochina and used for the plane and axisymmetrical problems [*Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk*, no. 2, 1940; no. 6, 1948]. Author obtains an upper limit for the water-free yield of the well in question for any depth of dividing line. He uses this assessment in the case of an anisotropic stratum, while, where the permeability of the stratum is greater horizontally than vertically, the water-free yield of oil proves to be higher. In addition it is proved to be impossible to completely fill the well with water if the output of the oil-bearing section of the stratum exceeds zero. N. N. Verigin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1540. Bernshtein, M. A., and Reitenbach, G. R., The investigation of strata containing high viscosity petroleum filtering through sand collectors (in Russian), *Neft. Kb-vo* no. 1, 53–58, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6896.

An investigation is made of the strata of high-viscosity petroleum at one of the Ukhtinsk oil properties, where the petroleum is forced out of the strata by means of oil shafts. The initial layer pressure in the stratum is equal to the saturation pressure. The stratum regime is determined by the authors as being a regime of dissolved gases. For the calculations of the unsteady petroleum filtration in the stratum, authors utilize the approximate method worked out by K. A. Tsarevich. Results of the calculations are given. Some proposals are put forward for working the oil-bearing sites. M. D. Rozenberg

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1541. Shekhtman, Yu. M., The inflow of liquid to a solitary vertical crack with a filter (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 7, 146–149, July 1957.

Hydraulic blast of a oil-bearing stratum results in cracks, both vertical and horizontal. For long and efficient service these cracks are filled with a permeable material. Perfomance of a vertical crack filled with a sand filter is solved in this paper after several simplifying assumptions. An expression for the oil inflow into well is obtained and some practical examples solved, giving an expected reduction in the conveyance through the filter as compared with a homogeneous stratum.

S. Kolupaila, USA

1542. Gheorghita, St. I., Slow movement of viscous fluids in porous media (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **4,** 343–353.

The investigated porous bodies are solid and hollow cylinder and sphere. Author uses following laws: for movement of the fluid around the cylinder and sphere, respectively, equations of Oseen; for movement in the porous body, equation of Darcy; in the cavities, equation of Stokes. On the surfaces the laws of Lyapunov are valid; the normal velocity components are continous and the usual hydrodynamic conditions are fulfilled. The number of equations is sufficient to determine constants; author therefor derives expressions for the velocity vectors and for pressures in the above cases. He investigates, then, the case when the porous body is very thin, and proves that in the range of small Reynolds number there is no linear relation between the normal component of velocity and the difference in the value of the pressure.

A. Kezdi, Hungary

Geophysics, Hydrology, Oceanography, Meteorology

(See also Revs. 1396, 1504)

1543. Thomson, W. T., Spectral aspect of earthquakes, *Bull. Seismol. Soc. Amer.* **49,** 1, 91–98, Jan. 1959.

Author considers ground acceleration associated with earthquakes to be simulated by a series of pulses of random amplitude, and with the time sequence of the pulses in an interval defined by an arbitrary probability distribution. Using a statistical analysis, the power spectral density is established. Numerical results are presented for the case of rectangular, half-sine and triangular pulse shapes. General result indicates that the power spectral density becomes a constant regardless of the wave shape and pulse timing, if the mean of the velocity pulses is zero. The problem is generalized to cover cases of varying pulse shapes and pulse duration. M. L. Baron, USA

1544. Smith, W. E. T., Bibliography of seismology, Publ. Dom. Observ. **22,** 2, 25 pp., July–Dec. 1957; Canadian Department of Mines and Technical Surveys, Ottawa, 1958.

1545. Popova, T. N., Results of laboratory investigations of the re-formation of river-bed streams at low pressure dams (in Russian), *Trudi In-ta Sooruzh. Akad. Nauk UzSSR* no. 7, 107–136, 1955; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6658.

The object of the study was to investigate the formations of deposits of silt in the "upper" waters of a dam; the erosion of the river-bed in the "lower" water of the dam by a flow free from bottom silt; the silting up of the river-bed in the "lower" water at large discharges of water and of the throwing off of such flow loaded with silt in the "lower" water of the dam. The experiments were carried out in a trough 34 m long, using (as silt) sand with particles up to 9 mm in diameter and locomotive scoriae up to 3 mm. Some qualitative results were obtained, on the basis of which author thinks it possible to establish the character of the silting up by deposits of the river-bed in the "upper" water of the dam, and also the erosion of the river-bed in the "lower" water and the silting up of the "lower" water by a flow loaded with bottom silt. The qualitative features thus obtained confirm the known qualitative circumstances. Paper leaves unanswered the question of similarity and of passing on results obtained in the model apparatus for check in natural conditions, nor is there any comparison made between the use of sand and scoria as the silting medium.

I. V. Egiazarov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1546. Sato, Y., Numerical integration of the equation of motion for surface waves in a medium with arbitrary variation of material constants, *Bull. Seismol. Soc. Amer.* **49,** 1, 57–77, Jan. 1959.

A numerical procedure, suitable for use with high-speed computers, is used to determine the dispersion of surface waves in media where material properties vary arbitrarily with depth. The dispersion of Love and Rayleigh waves is obtained by the numerical specification of surface displacement and a numerical integration of the equations of motion. Method consists essentially of a search procedure which yields the proper combination of parameters required for a solution which converges and satisfies the boundary conditions. For example, for Rayleigh waves, the wave number is fixed and a two-dimensional search in the a (ratio of horizontal to vertical components of displacement at free surface)—C (phase velocity) plane is used to locate the point which produces a convergent solution.

Method is tested on several cases with a known analytical solution and is then applied to the cases: (1) Love waves in a medium with constant density and linearly increasing rigidity; (2) Rayleigh waves in a medium with constant density and equal rates of increase of λ and μ; (3) sound waves in a medium where density and velocity are given by experimental curves.

M. L. Baron, USA

1547. Abecasis, F. M., Castanho, J. P., and Beja Neves, A., Long period waves in harbors (in Portuguese), *Minis. Obras Publicas, Lab. Engen. Civ., Lisboa, Publ., Tech. Pap.* 119, 28 pp., 1958.

1548. Toporkov, L. G., Research into the interference of the component waves in a tide, from the results of direct observations (in Russian), *Ucb. Zap. Leningrad Vyssb. Inzb. Morsk. Ucb-sbcba* no. 6, 28–33, 1957; *Ref. Zb. Mekb.* no. 7, 1958, Rev. 7662.

A method is proposed which enables the fact that interference exists, and the parameters of the waves interfered with, to be established on the basis of observations. The interference between two semi-diurnal waves in a tide, moving from the opposite sides of a channel of infinite length and constant section located at the equator, is examined. The author proves that although the amplitudes of the interfering waves will vary from section to section, the ratio between them will remain constant all the way along the channel. It is proposed that the ratio between the amplitudes of the lesser and greater of the interference waves should be called the "interference constant." The problem consists of determining this quantity from observations. There must be enough observations for an empirical curve to be drawn for the change in total wave amplitude along the channel. When d is used to signify the curve maximum at one of the sections, q to signify the minimum, author obtains the following to express the "interference constant"

$$\alpha = \frac{d - kq}{d + kq} \left(k = \sqrt{\frac{H_1}{H_2}} \sqrt{\frac{b_1}{b_2}} \right)$$

where H_1, b_1, H_2 and b_2 are the depth and width of the respective channel sections. All these quantities may be taken from a bathymetric chart and the empirical curve drawn for change in tide amplitude. As an example, author solves the problem for a tidal wave M_2 in the Malacca Straits, also using the cotidal chart for this wave in his calculations. He obtains a value for the "interference constant," and then also finds the amplitudes of the interfering waves. The greater the "interference constant," the closer the total wave is to stationary; thus, this quantity characterizes not only the change in amplitude of the component waves in a tide along the axis of a strait, but also enables us to assess the intensities of tidal channel flows in different parts of the strait.

O. R. Lundsberg

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1549. Kudryavtsev, N. F., Laplace's method for the calculations of the height of spring and rip tides (in Russian), *Ucb. Zap. Leningrad Vyssb. Inzb. Morsk. Ucb-sbcbe* no. 6, 23–27, 1957; *Ref. Zb. Mekb.* no. 10, 1958, Rev. 11176.

Laplace's method of calculating the height of tides is examined and reasons are given to justify the adoption of the maximum value of the tide coefficient $c_{max} = 1.20$ in the calculations. In conformity with Laplace's hypothesis in the expression for the height of the sea level, obtained by Laplace's method, the value β (the relation of the mean action of the Moon and of the Sun) is taken to be a constant and equal to 2.17. In fact, the value β is not a constant but depends on the locality of the observation post. It can be determined from working over the tide data by harmonic analysis. With β known for a series of points, calculations were made for the maximum value of the coefficient for the tide c_{max}. It appeared that when β varied a good deal, c_{max} varied little and was equal to 1.20.

E. P. Borisova

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1550. Metelitsyna, G. G., and Plakida, M. E., The height which a wave will reach on a steeply inclined wall (in Russian), *Rechn. Transport.* no. 9, 25–26, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7673.

Results are given of hydraulic race research carried out to determine the height water will reach on a wall set at a slope α varying between 45° and 90°. The theoretical solutions obtained by Senflu and Mishem for the case where $\alpha = 45°$ are extended to cover all the intermediate values of α. It is proved that the measured amplitudes of variation in the level on the wall practically coincide with the calculated figures.

B. Kh. Glukhovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1551. Sidorova, A. G., The heights reached by waves on banks (in Russian), *Sb. Trudi Mosk. Inzh.-stroit. In-ta* no. 20, 81–87, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7676.

An equation is proposed for determining the heights which waves will reach on banks.

$$b = \left(1.5 + 0.25\frac{\lambda}{b}\right) b \tan\alpha \exp\left(-2\frac{\Delta}{b}\right).$$

Here λ and b are the length and height of the initial wave, α is the angle at which the bank slopes to the horizontal, and Δ is the absolute roughness. It is noted that b decreases when the waves approach obliquely, also in the case of slopes which the waves have deformed. In the reviewer's opinion the equation gives exaggerated values for b where $\lambda/b > 15$.

V. L. Maksimchuk

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1552. Kurlovich, E. V., The question of fixing the holding limits of the banks of earthworks subjected to waves (in Russian), *Sb. Trudi Mosk. Inzh.-stroit. In-ta* no. 20, 93–99, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7679.

The upper holding limit for the earthwork banks of installations and coasts is determined from the condition

$$H_1 = h_2 + a$$

Here H_1 is the increase in the holding limit above the highest calm water level; h_2 is the height of the sub-shooring, which it is recommended should be determined by N. N. Dzunkovskii's method with a correction by A. V. Karaushev's method. The author determines the lower limit on the basis of the scourability of the soil under the action of a bottom layer velocity determined according to Bussinesq. The equation also provides good results for the variable depth case. Approximate values are given for the non-scouring velocities for particles of diameters between 0.1 and 150 mm, lying at slopes of 1 : 3.5 and 1.6.

A. S. Ofitserov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1553. Altunin, S. T., and Buzunov, I. A., Questions on the formation and calculations for streams of water catchment areas (in Russian), *Trudi In-ta Sooruzh. Akad. Nauk UzSSR* no. 7, 5–105, 1955; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6657.

Paper contains the following sections: Special features of the formation of streams in actual conditions and in hydro-assemblies. Calculations for streams in actual conditions; the width of the stable arm; discharge from the stable arm; the instability form. Calculation for the regulated stream. The motion of sediment on the bottom and the formation of river-bed streams at hydro-assemblies; formulas for the discharge of sediment and, on their basis, a comparison of the conditions in the upper actual layer with the conditions in the lower layer after removal of the water. Calculations for the formation of regulated river-bed streams when water is being collected in the lower reaches of the river's course. Calculations for the processes of re-formation of river-bed streams in the "upper water" of dams. These calculations for the "lower water." Determination of the possible depth of erosion, of the drop in water-level and of the length of the eroded portion. Calculations for the silting-up of the "lower water." Examples for the calculation of the river-bed channel at the damsite; collection and analysis of the original data for the calculation; selection of the discharges for the calculation; the calculation coefficients for the dam; selection of the velocities for the calculation of rate of formation; selection of coefficients for the stable width of the river-bed stream; selection of the coefficient of roughness and of types of formulas. Calculations for the river-bed stream in actual conditions; calculations for the river-bed stream of the river-bed-forming discharge; calculations for the mean long-period (covering many years) discharge beyond the time of intensive motion of bottom silt; calculations for the intermediate river-bed stream. Determination of the transporting capacity of the flow and discharge of bottom deposits. Calculations for the regulated river-bed stream in the "upper" and "lower" waters. Calculations for the processes involved of the re-formation of the river-bed stream in the "upper" waters of the dam. Similar calculations for the "lower" waters. An example of calculations for the regulated river-bed stream at a damsite in the low-lying portion of the river.

The prime considerations affecting the material listed appear to be: the large volume of tests in the natural investigations carried out by the authors in Central Asia and the empirical tests carried out in laboratory investigations of eroded river-beds by the laboratories of the Institute of Construction of the Akad. Nauk UzSSR and SANIIRI. The whole study represents an attempt at solution by calculation of a complex and many-sided river-rain process, extremely difficult to handle by means of analytical methods.

I. V. Egiazarov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1554. Vilenskii, Yu. G., and Glukhovskii, B. Kh., An experimental investigation of the process of sea agitation induced by wind (in Russian), *Trudi Gos. Okeanogr. In-ta* no. 36, 9–62, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5366.

The results obtained from experimental investigations of storms at sea due to wind are given; materials are produced, collected from synchronous instrumental observations on the wind and waves in a number of strong ocean storms. Single and two-dimensional functions of distribution obtained earlier are confirmed by new observational matter, collected on the Caspian and Baltic seas. The question is investigated of the deformation of sea waves at the point of impact with shoal water. Authors examined the changes of mean values of the wave-elements or the value of these elements for one or other standard. With decrease in the depth of the sea there is a reduction in the height variations of the waves, while the period variations show practically no change. The function for the distribution of wave heights is found by means of the determined dependence of the relation of the mean height of the wave to the depth of the sea. In the zone of wave disruption the distribution of heights coincides with the distribution of periods. The functions of distribution of heights and lengths of waves are given in tabular and graphical form. Data are furnished regarding the change with depth of the mean values of the periods and heights of the waves.

From authors' summary

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1555. Byzova, N. L., Air temperature formations above the sea with currents operating (in Russian), *Trudi Mor. Gidrofiz. In-ta, Akad. Nauk SSSR* **7**, 126–134, 1956; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6842.

The equation is solved:

$$\frac{\partial\vartheta}{\partial t} = \frac{\partial}{\partial z}\left[k(z)\frac{\partial\vartheta}{\partial z}\right] + f(z, t)$$

with $-H < z < 0$ (the sea)	$k(z) = k_1 = \text{const}$
with $0 < z < h$ (the air)	$k(z) = k_2(1 + mz)$
with $h < z < l$ (the air)	$k(z) = k_3(1 + mh) = \text{const}$

where ϑ is the temperature, t the time, z the vertical coordinate, $k(z)$ the coefficient of exchange, the function $f(z, t)$ is equal to zero in the air and is taken to be known in the water.

The equation is solved in conditions of arbitrary initial distribution of temperature and corresponding boundary conditions by the

method of natural functions. It should be noted that problems, analogous to the one in question, and perhaps more generalized, were investigated in the works of N. R. Malkin [see for instance, *Izv. Akad. Nauk SSSR Ser. Geogr. i Geofiz.* no. 5, 1944; Tr. Nauchno-Issledovatel'skikh Uchrezhdenii, Tsentral'nyi Institut Prognozov. Teoreticheskaya Meteorologiya. Ser. 1, 1947, (30)].

E. N. Dobryishman

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1556. Lineikin, P. S., Wind currents on the high seas (in Russian), *Meteorol. i Gidrol.* no. 12, 26–33, 1956; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4165.

A short review of the author's work on the theory of wind currents on a deep heterogeneous sea. The principal assumptions made by him in deriving the basic equations for the problem of the dynamics of the currents are referred to: linearization of the equation of motion, conditions pertaining on the free surface and equations for the condition of the sea water, and also the averaging by depth of the values of the coefficients of turbulent exchange and initial vertical gradient of consistency in the sea. To the system of equations of motion and continuity, customarily adopted in the theory of sea currents, author adds the equation of the turbulent diffusion of water masses, permitting, together with others, the determination of the projection of velocities, u, v, w and the disturbance of density δ of the sea water drops. When looking for special solutions for δ in the form $\delta = F(x, y) \exp(-kz)$ and the determination of value k from the solution of some characteristic equation it proved to be possible, in conformity with the relative values of the parameters of the problem, to separate out the solutions, slowly fading with depth, reflecting the effect of the heterogeneity of the liquid and of the planetary rotation, and the known solutions of the Eckman type, dieing in the friction layer in the sea. Author introduces a concept of "the depth of barometric taper" H, making a determination of its value by means of the same criterion of diminution with depth of the slowly fading disturbances by $\exp(-\pi) \sim 0.043$ times, as Eckman used for the determination of the depth of friction. With the characteristic values of the parameters for the given problem $H \sim 1000$ m was found. Some other deductions are given which were arrived at when investigating a number of special cases. The order of the calculated values for the horizontal and vertical components of velocity, for the mean declination of the sea level, and also for other characteristics of the process, in particular for the dynamic ascent of deep water, corresponds with the data of actual observations. An evaluation is supplied of the extent of error permissible when replacing the actual velocities of the flow lower than the friction level by geostrophic velocities. Results are also furnished for the investigation of the nonstationary problem: evaluation of the periods required for the establishment of surface and deep currents, the sequence of development and establishment of pure-drift and gradient-convection elements of flows, and so forth. Results are given of the analysis of steady flows in a semi-confined sea, during the operation of a homogeneous wind in a coastal zone.

From author's summary

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Book—1557. Instruments for the study of atmospheric pollution, 3rd ed., (Committee on Air Pollution Controls), New York, The American Society of Mechanical Engineers, 1959, 34 pp. $2. (Paperbound)

A survey of instruments for studying atmospheric pollution, commercially available in America, is organized under three main headings:

(1) An outline list of instruments serving the various purposes (indicators and recorders for smoke density; sampling, measuring and counting particulate matter; sampling and analyzing gases, vapors, and liquids; auxiliary devices for sampling air and gases).
(2) Specific types of instruments listed according to function.
(3) Alphabetical list of 286 American manufacturers and laboratories of the various instruments, with complete addresses. A very thorough cross referencing facilitates finding the manufacturers of a certain type instrument, and vice versa.

K. J. DeJuhasz, USA

1558. Keitz, E. L., Differential advection as a factor in clear air turbulence, *J. Meteorol.* **16,** 1, 57–62, Feb. 1959.

Clear-air turbulence observations made by accelerometer measurements have been correlated with six-hour forecasts of the change in vertical stability. The change in stability has been forecast by computing the six-hour horizontal temperature advection at two levels. By means of the Kolmogorov-Smirnov nonparametric test for cumulative distributions, a significant correlation has been shown to exist between the observations of turbulence and the forecast change in stability. However, no significance has been established regarding the magnitude of the turbulence.

From author's summary

1559. Gugnyaev, Ya. E., and Shaitan, V. S., A procedure for computing the wind velocity for forecasting reservoir wave conditions (in Russian), *Trudi Gidravl. Labor. Vses. N.-i. In-ta, Vodosnabzh., Gidrotekhn., Sooruzh. i Inzh. Gidrogeol.* no. 6, 87–94, 1957; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7669.

The dimensions of wind-formed waves depend on the wind velocity and its dissipation. A. P. Braslavskii [*Tr. Gos. Gidrol. In-ta* no. 35, 1952] recommends that the calculated wind velocity over a reservoir should be computed according to standard observations carried out at meteorological stations on land, introducing two coefficients to allow for the height at which the measuring instruments are installed and the features of the locality. Authors recommend the introduction of an additional coefficient K to allow for the effect exerted by the surface of the reservoir, and its magnitude in the direction of the wind's effect (dissipation), on altering the wind velocity. A relationship is given between the coefficient K and the amount of dissipation; this relationship has been obtained by comparing data from observations, covering many years, of wind velocities at various meteorological stations before and after the reservoirs were filled. K is always greater than unity; for a distance of 100 km, $K = 1.4$.

Ya. G. Vilenskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1560. Singer, I. A., and Raynor, G. S., Variation of the wind profile with meteorological parameters, Proc. Sixth Midwest. Conf. Fluid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 1959, 98–117.

Naval Architecture and Marine Engineering

(See also Rev. 1166)

Book—1561. Proceedings of Symposium on the behaviour of ships in a seaway, Vol. I and II, 25th Anniversary of the Netherlands Ship Model Basin, Wageningen, Sept. 7–10, 1957; Wageningen, H. Veenman & Zonen N. V., 1959, 589 pp., 462 pp. (Paperbound)

These volumes contain some fifty technical papers and associated discussions presented in 1957 in Wageningen, where one of the most advanced European ship towing tanks is located. The two-years' delay in publication is somewhat unfortunate in the

rapidly advancing field of seaworthiness; nevertheless, the discriminating reader will find a sufficient amount of information which will reward him for wading through over 1000 pages.

The major technical areas covered are: (1) applications of the power spectrum method; (2) theoretical aspects of ship motion; (3) full-scale observations; (4) model experiments; and (5) laboratory technique.

Papers were contributed (as opposed to "invited") and represent a broad spectrum regarding subjects as well as quality. These volumes testify that the influence of the "rule of thumb" designers and of the experienced sea dogs is complemented by systematic scientific research and engineering development.

V. G. Szebehely, USA

1562. Doust, D. J., and O'Brien, T. P., Resistance and propulsion of trawlers, *N. E. Coast Inst. Engrs. Ship., Trans.* **75**, 7, 355–436, May/June 1959.

A statistical analysis of all resistance data for trawlers, obtained from model experiments conducted in No. 1 Tank, Ship Division, National Physical Laboratory, has been made. From an analysis of this type, a design method has been evolved, by means of which optimum resistance characteristics can be estimated for each trawler type, together with predictions of effective horse power for any particular form.

These e.h.p. calculations can be made by determining six parameters from the normal ship's lines plan, and to facilitate the computation of results a program has been prepared for a digital computer (DEUCE), so that the N.P.L. can provide an estimated e.h.p./speed curve very quickly for a given set of parameters. In addition, design diagrams have been prepared for practical use in design offices.

From the propulsion aspect a series of propellers of 0.60 blade area ratio has been tested in open water over a wide range of slip, and forms part of the N.P.L. standard series. Some of these, together with additional propellers of the standard series type, have been tested in open water, under cavitating and non-cavitating conditions in the Lithgow water tunnel and behind a model of a bulbous-bow trawler.

From these three types of experiments, the most suitable propeller characteristics have been determined for free-running and trawling conditions. An analysis of existing N.P.L. propulsion data for trawlers has been made and propulsion factors for design and estimating purposes have been derived.

From authors' summary

1563. Kostyukov, A. A., Theory and calculation methods of wave-forming by, and wave resistivity of, ships (in Russian), Avtoref. Diss. Kand. Tekhn. Nauk In-ta Mekhan. Akad. Nauk SSSR, Odessa, 1957; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 719.

1564. Paulling, J. R., and Rosenberg, R. M., On unstable ship motions resulting from nonlinear coupling, *J. Ship Res.* **3**, 1, 36–46, June 1959.

Nonlinear equations for the forced motion of a ship having the three degrees of freedom of heave, pitch and roll are investigated. It is assumed that the ship has no mean motion. The nonlinear forcing terms included in the equations are of the second order and are products of two different displacement variables; some of these may vanish by symmetry. Other quadratic terms of the same order are omitted, but authors believe that their conclusions will remain qualitatively applicable. In this way a system of three simultaneous ordinary differential equations is obtained, and is studied on the assumption that one of the space variables is constrained to vanish. Thus when the pitch vanishes the heave is found to be simple harmonic and the roll to obey a Mathieu equation, with possible instabilities when the natural frequency of roll is near to half the frequency of heave, or near to the frequency of heave. Similar results hold for the pitch-roll motion. The heave-pitch system is discussed on the assumption that the roll vanishes and also that the heave is simple harmonic. (It seems to the reviewer that the latter assumption conflicts with the first equation [27].) Experiments on the roll-heave motion agree qualitatively with the theoretical conclusions. F. Ursell, England

1565. Khomenko, V. S., Motion of a ship in a shallow channel (in Russian), *Izv. Akad. Nauk. SSSR, Otd. Tekh. Nauk* no. 10, 99–102, Oct. 1957.

Following linearized problem is treated: A wall-sided ship defined by its water line glides on the bottom of a rectangular shallow channel with constant supercritical speed. Generalizing a method due to Joukowsky a velocity potential and the resistance function are established using a Fourier integral representation. Results agree with those obtained by applying limiting procedures to known solutions for singularity distributions. The resistance is analyzed as a function of the Froude number $F = v/(gb)^{\frac{1}{2}}$ and of the ratio channel width b divided by ship length L. Graphs evaluated for a parabolic water line show that on the average the wave resistance in this region of speed decreases with decreasing b/L. This agrees with known results. Because of oversimplification of basic assumptions, quantitative results should be checked by experiments. G. P. Weinblum, Germany

1566. Fadeev, Y. I., Investigation of the roll of model ships on steady and wavy surfaces (in Russian), Avtoref. Diss. Kand. Tekhn. Nauk Mosk. Tekhn. Inst-t Rybn. Prom-sti i Kh-va, Moscow, 1957; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 720.

1567. Radosavljevic, Lj. B., The influence of the inclination of the sides of the ship on her motion in a seaway (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **2**, 255–265.

1568. McGehee, J. R., and Johnson, V. E., Jr., Hydrodynamic characteristics of two low-drag supercavitating hydrofoils, NASA Memo 5-9-59L, 64 pp., June 1959.

Aspect-ratio-1 and aspect-ratio-3 hydrofoils were tested for a range of cavitation numbers from 0 to approximately 6. The aspect-ratio-1 hydrofoil was also tested at zero cavitation number with two sets of end plates having depths of 3/8 and 1/4 chords. The experimental results for the hydrofoils without end plates were compared with a three-dimensional zero-cavitation-number theory.

From authors' summary

Friction, Lubrication and Wear

(See also Rev. 1093)

1569. Wisander, D. W., Maley, C. E., and Johnson, R. L., Wear and friction of filled polytetrafluoroethylene compositions in liquid nitrogen, *ASLE Trans.* **2**, 1, 58–66, Apr. 1959.

Bearings and seals of missile power plants have to work under extreme conditions, and it is necessary to investigate materials at very low temperatures for this purpose.

Experiments were performed with a sliding-friction apparatus of which a hemisphere-tipped (3/16-in. radius) rider specimen slides on the flat surface of a 304 stainless-steel (2½-in. diam) disk at a usual rotating speed of 2300 fpm and a test load of 1000 grams, while the test pieces were submerged in liquid nitrogen (−320 F).

At these conditions PTFE (polytetrafluoroethylene) materials of molded form and extruded form with different fillers, including carbon, graphite, glass, metal and ceramic, in concentrations up to 25%, showed very good wear and friction properties; the extruded materials were slightly better. All PTFE types had lower

friction coefficients and wear than other reference materials (metals, carbons, plastics).

Especially one glass-filled PTFE specimen showed excellent results up to sliding velocities of 6000 fpm. The reviewer believes, however, that, at least in this case, fluid friction is responsible to a large extent for this behavior.

E. Gülker, Germany

1570. Jerman, R. B., Williams, R. C., and Leeser, D. O., Evaluation of material wear and self-welding in sodium-cooled reactor systems, *ASME Trans.* **81**D (*J. Basic Engng.*) 2, 213–225, June 1959.

Laboratory and prototype component tests were made to determine the degree of adhesion and self-welding of various bearing-couple materials in liquid sodium. A few tests were run in nitrogen and in argon. Temperatures were from 500 F to 1000 F and the static loads on the bearing surfaces were up to 10,000 psi. The harder materials showed better wear resistance generally than did the softer materials. However, each material has a service life depending upon the temperature, unit loads, nature of service, and environment. From authors' summary

1571. Vydrin, V. N., Amosov, P. N., and Kossovskii, L. D., A method for determining the wear of rolling-mill rolls, *Indust. Lab.* **24**, 1, 87–88, Feb. 1959. (Translation of *Zavod. Lab., SSSR* **24**, 1, 88–89, Jan. 1958 by Instrument Society of America, Pittsburgh, Pa.)

1572. Lueg, W., and Funkejun, P., Measuring the wear in drawing steel bars with a radioactive drawing tool (in German), *Stahl u. Eisen* **79**, 14, 996–1002, July 1959.

Survey on the wear measurements carried out up to present in cold drawing includes determination of the abrasion by means of an activated drawing tool, carrying out the test, test results and their interpretation in connection with the drawing conditions.

From authors' summary

1573. Hirst, W., The mechanical wear of metals, *Brit. J. Appl. Phys.* **9**, 4, 125–132, Apr. 1958.

1574. Kingsbury, E. P., and Rabinowicz, E., Friction and wear of metals to 1000C, ASME Lub. Conf., Los Angeles, Calif., Oct. 1958. Pap. 58-LUB-6, 4 pp.

1575. Drutowski, R. C., Energy losses of balls rolling on plates, *ASME Trans.* **81**D (*J. Basic Engng.*) 2, 233–238, June 1959.

Apparatus for measuring the rolling force of a ball supported between two plates is described. The rolling force is an extremely small quantity compared to the normal force. Instantaneous values of the rolling force vary greatly from point to point on the sample surface and this variation is explained in terms of surface roughness and material homogeneity. The energy losses of balls rolling on plates are shown as functions of load, material, and surface roughness. The rolling of a ball on a plate is examined as a cyclic process in which elastic hysteresis losses appear to be the primary source of energy dissipation. An analysis involving the Hertzian contact stress field is used to derive an equation relating the rolling force and the material damping capacity.

From author's summary

1576. Hori, Y., A theory of oil whip, *ASME Trans.* **81**E (*J. Appl. Mech.*) 2, 189–198, June 1959.

Equations governing displacement of a transversely loaded journal away from the equilibrium position are nonlinear; if they are linearized they give stability condition for displacements which are small in comparison with eccentricity due to load. Motions in which displacements are larger than this, and in which journal describes orbit whose diameter may be almost as large as diametral clearance, are governed by different stability conditions and shaft can only be thrown into such an orbit by a suitable disturbance. Author obtains both sets of stability conditions and also discusses variation of whip amplitude with shaft speed. He uses his theory to explain some experimental results reported by other workers.

Paper is a useful contribution to our understanding of oil whip.

D. C. Johnson, England

1577. Milne, A. A., On the effect of lubricant inertia in the theory of hydrodynamic lubrication, *ASME Trans.* **81**D (*J. Basic Engng.*) 2, 239–244, June 1959.

This is another discussion on the effect of lubricant inertia. Expressed in terms of the stream function, the two-dimensional Navier-Stokes equations for a slider bearing with no side leakage are solved by the small perturbation method. With known zeroth-order term the paper gives the first-order term. This solution is essentially the same as that given by Kahlert [*Ing. Arch.* **16**, p. 321, 1948] when the wedge angle is small.

L. N. Tao, USA

1578. Tao, L. N., On journal bearings of finite length with variable viscosity, *ASME Trans.* **81**E (*J. Appl. Mech.*) 2, 179–183, June 1959.

This is an extension of the author's earlier work for the constant viscosity case [*Quart. Appl. Math.* **17**, no. 2, 1959] to the case when the viscosity is variable and is an exponential function of pressure alone. The nonhomogeneous Reynolds pressure equation is reduced to a homogeneous equation which is solved by separating the variables. Finally the problem is formulated as an eigenvalue problem in Heun's equation, and mathematical expressions for the attitude angle and the upper and lower bounds of the load capacity are given. Reviewer notes that numerical work on both the problems of the author is being done by Mr. S. Ramachandra, I. I. T., Kharagpur, India, and the results will be published in *Trans. ASME.* S. D. Nigam, India

1579. Sternlicht, B., Reid, J. C., Jr., and Arwas, E. B., Review of propeller shaft thrust bearings, *J. Amer. Soc. Naval Engrs.* **71**, 2, 277–289, May 1959.

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BENETIN, J., Pohyb vody v zemine, Bratislava, Slovenska Akademia Vied, 1958, 215 pp. Kcs 16.60. (Paperbound)

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COMOLET, R., Introduction a l'analyse dimensionnelle et aux problemes de similitude en mecanique des fluides, Paris, Masson et Cie, 1958, 116 pp. 1 600 F. (Paperbound)

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GOURSAT, E., A course in mathematical analysis, Vol. I: Applications to geometry, expansion in series, definite integrals, derivatives and differentials (translated from French by E. R. Hedrick), New York, Dover Publications, Inc., 1959, viii + 548 pp. $2.25. (Paperbound)

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Proceedings of the Second Japan Congress on Testing Materials, Kyoto, October, 1958; Kyoto, Japan Society for Testing Materials, 1959, ix + 244 pp. + appendix.

RUZICKA, J. E., edited by, Structural damping (Colloquium on Structural Damping, ASME annual meeting, Atlantic City, N. J., Dec., 1959), New York, American Society of Mechanical Engineers, 1959, ix + 165 pp. (Paperbound)

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STOMMEL, H., The Gulf stream, a physical and dynamical description, Berkeley, Calif., University of California Press, 1958, xiii + 224 pp. $6.

Symposium on the Basic Mechanisms of Fatigue, 61st Annual Meeting, Boston, Mass., June 23, 1958; Philadelphia, American Society for Testing Materials, 1959, v + 121 pp. $3.75.

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VARLET, H., Usines de derivation; Tome I: Captage des eaux canalisations a ecoulement libre; Tome II: Conduites forcees tunnels d'amenee en charge usines souterraines, Paris, Eyrolles, 1958, 341 pp. 4 920 F; 1958, 274 pp. 4 673 F.

WOLFLE, D., edited by, Symposium on Basic Research, Rockefeller Institute, New York, May 1959; Washington, American Association for the Advancement of Science, 1959, xx + 308 pp.

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